THE ENGINEERING MAGAZINE

THE WORLD IS ITS FIELD

VOL. XXVIII. DECEMBER, 1904. No. 3.

THE CAUSES OF ACCIDENTS ON AMERICAN RAILWAYS.

By F. W. Haskell.

American railways, which have been the world's envy in the matter of freight equipment and economical freight handling, have attained a bad eminence through the awful record of accident in the conduct of their passenger business. Mr. Haskell's thoughtful discussion deals, from a wholly American point of view, with a matter which, instead of ameliorating with time and progress, as should rightly be expected, has increased in gravity until it dismays observers on both sides of the Atlantic. We believe him to be right in seeking the explanation in fundamental tendencies, lying deep below the apparent factors of equipment and organization. We are very sure that Mr. Haskell, like ourselves, will feel more than satisfied if his argument opens a discussion which shall lead the way to a remedy of the manifest evils of the present order.—THE EDITORS.

ONE must indeed be calloused who can read without a growing sense of horror the almost daily accounts of wrecks and loss of life in our American railways. A spirit of National pride prompts us to resent comparisons between the results of the operating of American and foreign railways; but no amount of sophistry can reason away the gruesome record, nor the unpalatable fact that in our country of greatest railway development, life is, by comparison, lightly held.

The record is there for all to see. How can the slaughter be stopped? Before a remedy can be applied, the cause must be discovered—and there must be a cause.

In contemplating so tremendously serious a matter as this, it is unfortunate that the force of many otherwise able discussions on the subject is weakened by an attempt to prove too much. For instance, in a

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recent issue of the *Outlook* it was suggested that one of the causes of railway accidents was the parsimony of railway managers in refusing to provide safety devices, or refusing to buy materials of sufficient strength. In other words, that with railway managers, avarice outweighed humanity. This suggestion is an expression of that unfortunate sentiment which arrays mass against class by advancing the doctrine that the man of wealth measures blood by dollars. It is the sentiment which gave birth to the faulty saying that "corporations have no souls." That sounds well, and is literally true. But corporations are owned and managed by men who are as apt to have souls as are the men who happen to be employed by individuals. It would be difficult to demonstrate that the contemplation of suffering and death is more agreeable to the corporation or railway officer than to the average man outside of these classes.

But, eliminating all humanitarian instincts, and placing the matter on a purely sordid basis—is it not self-evident that it "doesn't pay" to save a thousand dollars in the cheapening of materials and thereby lose a hundred thousand dollars in damage claims? Railway managers are usually broad and able men, and they are as quick to see and act on this truth as would be the mass of their critics.

In an article of this kind it would be foolish to attempt to cover the entire field of accidents which are incident to railway operation. By far the greatest number of fatalities are among those who may be broadly classed as "others" or "trespassers." We have too many grade crossings, and people are too prone to use railway tracks as park ways; but this class of accident is one which requires contributory negligence on the part of the victim, and will be eliminated from this discussion.

Among train accidents there are some which may be classed as practically unavoidable. The best and strongest rail may break, and no system of track inspection can cover every foot of rail during every minute of time. Then there are causes which may be called "acts of God."

Eliminating, again, all of these causes, this discussion will be confined to that most disgraceful, because entirely avoidable, class of accidents—train collisions.

Another digression will be made here to allude to a most illogical cure for railway wrecks which has recently been strongly dwelt upon by the daily press. It has been noticed that in collisions the mortality is chiefly confined to the passengers in day coaches, while the more solidly built Pullman protects its occupants from serious harm. It is urged as a cure for this that day coaches be built as strongly as are

Pullmans. Of course such a procedure would be productive of considerable good; but the collision of two rapidly moving trains composed entirely of Pullman cars would be almost sure to result in some little discomfort to their passengers. Make strong cars. But to avoid loss of life from collision, stop the collisions.

Most railways of any importance in America are solidly built, and well equipped. The so-called standard lines have spent money lavishly in providing all the safety devices known to the profession. On some lines it would be difficult to find a place where another dollar could be expended so that it would increase the factor of safety. It is a matter of record, also, that many of the most disastrous wrecks of recent years have been on those roads which are equipped with the most elaborate systems of train-protecting devices.

Very few accidents have their prime cause in insufficient or defective material or equipment, while the vast majority of them result from errors in operating. The handling of trains is governed by the standard rules. These rules are the results of fifty years of experience; and, in their present form, are well-nigh perfect. In fact, it is almost inconceivable that an accident could occur where the standard rules have been faithfully observed.

Given then, a solid road bed, heavy rails, strong equipment, proper signals, and almost perfect operating rules; why do we have the almost daily murder of passengers from preventable accidents?

Because the admirable rules for the government of employes are habitually disregarded.

We are prone to speak with something like contempt of the average Englishman's blind slavishness to "regulations," and to compare it to its disadvantage with our superior fashion of disregarding fixed rules and using individual intelligence. But we, with our quicker intellects, kill our passengers, while the "dull-witted" Englishman carries his in safety.

The underlying cause of the frequent disregard of railway rules, is that peculiar National unrest which chafes at all restraint. In the higher official it takes the form of risking much to make a reputation of accomplishing much. In the lower grade of workman it is principally an instinctive propensity to defy authority as far as dared. And the two work together for evil.

There are many train rules which are habitually broken by train men whose superiors know of the violations. And the men who break the rules know that their superiors know it, and wink at it—so long as no accident results.

On all roads the rules provide that when a train is stopped except at a scheduled station, a flagman must go back a sufficient distance to stop any train which might overtake the first.

On the better equipped roads, the line is divided into "blocks," with signal towers or bridges every few miles. The signal is generally automatic, and shows danger if a train is between it and the next signal, and clear if the block is empty. The rules direct absolute obedience to the signals.

Now either the flagman or the block signal, if properly performing his or its function, is an absolute safe-guard. The two together should make a rear-end collision impossible—but instead of that, by dividing the responsibility, they frequently cause disaster. Some of the most disastrous wrecks of recent date have been rear-end collisions on roads having a full installation of perfected block signals. In fact, the records will perhaps show more of this class of accidents on roads equipped with block signals than on roads which are not so protected.

On lines having a dense traffic, a delay to one train may affect a dozen others. Officers who could not be bribed by wealth will wink at chances being taken which may save their division from congestion.

A heavy train is behind time and comes to a red block. That signal means that another train is somewhere on the next block—possibly three or four miles away. To obey the signal and stop, means loss of time and delay to a following train and to other trains waiting at junction points. To go ahead would almost certainly result in no damage, for the train ahead will probably get off the block before being overtaken, and will be side-tracked or will regain its headway before the next block is traversed—besides, if the following train gets too close, the flagman will be out to stop it.

A train is unexpectedly stopped between stations. The rules provide that a flagman must go back a very considerable distance. It is snowing. A long tramp means wet feet. The flagman reasons: "We will be here only a few seconds anyway. I will be called in before I can get back to my post, and then the train will be delayed while I am running back to it—besides, the block signal will hold back any following train."

These things are done habitually. I have talked to old railway men. The consensus of their statements is this: "Yes, the rules say so-and-so. But the man who gets his train in on time is the one who makes a record; and the man who, by faithfully obeying all the rules, gets in the habit of coming in late, is told that if he can't make time,

some other man will. Oh! if we have a wreck, then it is up to us for disregarding rules."

Many roads having installed a perfect system of block signals, destroy its entire effectiveness by establishing the "permissive block" or "going ahead under green." By this system a following train is given discretionary power to run into a block already occupied. This permission is always coupled with the injunction that the engineer must use caution, and "at all times have his train under perfect control." But in actual operation "caution" usually means not exceeding the maximum possible speed of the engine.

I once stood by the side of a busy line, with the signal engineer of the road. This line had a complete installation of block signals. We watched a dozen heavy freights rush by at thirty miles an hour, with not a hundred yards of daylight separating any two of them. I expressed surprise at the reckless disregard of signals, and the officer said: "Freights run regardless of the blocks. We couldn't get them over the road if we kept them a block apart."

I was once riding on the rear car of a through passenger train. We were being closely followed by the second section of the train. Our section was stopped in a deep rock cut, on a sharp curve. It was a very dark night and was raining hard. I went to the rear platform, and for fully three minutes listened to the conductor and flagman swear about the weather. Finally the conductor said: "Well, I suppose you'll have to go back." The flagman started back, but had not gone two car lengths when the conductor yelled to him that was far enough. Half an hour later we reached the terminus of the division, and we had not come to a full stop when the second section rolled in on an adjacent track.

On the return trip of the same journey, I was again in the rear car. It was night, but clear. Our train stopped between stations and again I went to the rear platform. In a few minutes I heard the roar of an engine's exhaust. Then a head-light showed, the noise of the exhaust ceased, and I could hear the application of the brakes. The locomotive of the following train stopped within twenty feet of the rear of my car. I said to a brakeman: "Isn't this division equipped with block signals?" He replied: "Yes, but that is the second section of this train." I said, "Oh, I see. It doesn't hurt to be hit by another section of the same train." The brakeman said nothing but looked weary, and left me.

No accident resulted in either of these cases; but in one was a total disregard of the flagging rule, and in the other a total disregard of the

block signal. In neither case was there any attempt at concealment, the clear impression being given that taking chances of this kind was all in the day's work.

A few years ago, during the night and in a dense fog, two sections of a fast train were bowling along a main track. The first section was unexpectedly stopped; and the second section was also unexpectedly stopped—about half way through the first. A dozen passengers were killed. The line was equipped with block signals, and the block was set against the second section. The engineer of the second section said in his explanation of the accident that the fog was so thick that he could not see the signal.

A very proper rule in the standard code is that the inability to see a signal where one should be, must be regarded as a danger signal, and the train brought to a full stop.

I spoke to an old locomotive engineer, and he said: "Why, my dear sir, if we followed all the rules we would never get a train in. That fellow did exactly what I would have done, and if he hadn't done it a thousand times before he would have been wiping in the round house or running a peanut stand instead of an engine."

It was reported in the press not long ago that a party of officers of a large Western system decided to test the faithfulness of their men. They went to a signal station and removed the light from the semaphore. According to the rules, the first train that came along should have stopped and asked where the light was. Twelve trains in succession passed that point at full speed; and it was rumored that the officers, fearing there would not be any men left to run their trains, let the hint go out which stopped the thirteenth train.

The examples cited above are of the disregard of rules with the implied connivance of the superior officers of the train men. It must be apparent that the mischief cannot be stopped right there. The general understanding that some rules may be broken has a far-reaching effect in the steady demoralization of the men. The sense of moral responsibility grows weaker and finally disappears. Beginning with an occasional exercise of "discretion," with the tacit consent of his superior, an engineer gradually becomes a free-lance, disregarding all restraint and violating rules which the most reckless despatcher would see the necessity of obeying.

In the rear-end collision last year, on the Central of New Jersey, the engineer of the following train disregarded the red block, the waving lanterns of two flagmen, and the tail lights of the first train, into which he plunged.

In a butting collision a few months ago, in Michigan, the engineers of the opposing trains saw each other's head-lights on a straight track, for *four miles.*

It is impossible to imagine the co-incident insanity of both engineers; and we are left with the only hypothesis that habitual contempt of orders and discipline had rendered these two men physically as well as morally irresponsible.

Every added mechanical device for the protection of trains (short of one which in spite of the efforts of the train men would automatically stop and hold a train) is an added source of danger, *until* every man connected with the train service is drilled to the point that he would murder his mother in cold blood as soon as he would disregard an order or a signal. Until personal moral fibre is recognized as being the only safe foundation for the handling of trains, the additional safety afforded by a "safety device" is more than counteracted by the resulting division of responsibility.

As I have attempted to show in this article, the vast majority of all train accidents are the results of disregard of orders; and the habitual disregard of orders results from that moral degeneration which has, perhaps unconsciously, been largely brought about by the passive, if not active, attitude of railway officers. There is, however, another cause which is a factor of considerable influence. It will be difficult to give this factor its true value, and, indeed, any mention of it is sure to be met with vigorous and indignant denial. This factor is the influence of labor organizations.

It is recognized that a law without a penalty cannot be enforced. The law, recognizing the perils attaching to certain operations, invests certain responsible men with temporary power which is almost despotic. The responsible officer in the army, the navy, or the merchant marine, has the absolute power to enforce his orders.

The disregard of a train order or signal may mean death to dozens of helpless people. A railway officer should have the power not only to make rules, but to enforce them; and to enforce them, he must have the absolutely unhampered right to inflict penalties—the nature of these penalties being suspension or discharge. There was a time when the discharge of a railway employee by his division superintendent was final. No one ever thought to question it. No doubt there were some unjust dismissals, and personal spite probably played an unfortunate part. But, on broad grounds, an occasional injustice to an individual is of slight moment as compared to the safety of the traveling public and the great body of train men. And,

at the worst, the proportion of unjust charges was probably very small. In the general march of progress, however, there has come about a refinement in the sense of justice, which has reached railway officers as well as other people, and with the present universal right of appeal it is almost impossible for a man to receive his final discharge unless he deserves it.

Because of these changed conditions which safe-guard the employee's tenure of employment, there is no general principle nor specific reason why the disciplining of train men should not be absolutely in the hands of their employers, without the possibility of outside interference.

On many roads, the slighest discipline, for any reason whatever, even for disregard of train orders, is habitually and persistently combatted and resisted by labor organizations. Of course, the personal equation comes in here largely, and many "locals" of labor unions are in the hands of inelligent and responsible men. But, as a matter of form, a "committee" calls to get the reason for the discharge of a fellow unionist. If the cause is sufficient, that sometimes ends it. But frequently the soundness of the reason is disputed; at other times it is recognized, but the official is urged to let the man off "just this time." In extreme cases the reasons are recognized, but the official is ordered to restore the man anyway, or stand a strike. Naturally enough, extreme cases of interference bring their own correction, for when an abuse becomes intolerable it is rebelled against. But, as in the causes spoken of earlier in this article, the great evil of "union" interference is directly apparent in the undermining of the moral sense.

A superintendent who knows that every attempt at discipline will involve him in a dreary discussion with a silver-tongued or obstinate spokesman of a committee, grows very weary, and is apt, for this reason, to disregard minor infractions of rules, where if he felt entirely free he would insist upon the maintenance of standard.

A train employee who knows that a committee will always act as a buffer between himself and his superior, becomes indifferent to exact obedience of rules.

To sum it all up: The cause of a vast proportion of our railway accidents is disregard of rules.

The disregarding of rules is the result of a moral degeneracy on the part of both train men and their superiors.

The moral degeneracy is the result of a criminal willingness to take chances on the part of officials, which has been communicated

to their subordinates; and to laxness of discipline both on the part of the official and the men.

The cure for this is the cultivation of a sense of moral responsibility, upheld by the most absolute and exact discipline.

It may be claimed that the causes which I have suggested are obscure and remote, and that the proposed cure is visionary and, by its nature, impractical. That to revise the moral natures of an army of train employees is an utopian dream; and that its accomplishment would require a generation of training.

Unfortunately, such criticism would include much truth; but the nature of the disease with which we are contending is such that it cannot be cured "while you wait." We have no aching tooth to be pulled out; but polluted blood and debilitated nerves which must be slowly coaxed back to a healthy condition. If the railway carnage could have been stopped by the introduction of some mechanical device, or by the changing of some operating rule, the conditions which have afforded the reason for writing this article would have passed by years ago.

The train rules as they now exist are adequate to cover practically every point in train movement, and they require very little in the way of amendment or addition. Men who habitually disregard existing rules, will hardly give closer attention to revised rules; and a careless or a wicked man cannot be made a careful or a good man by legislation. But in order to offer a little that is concrete among the much which is abstract, I submit the following suggestions for

Supplementary Train Rules

A. No train employee may be required, *nor permitted,* to be on duty for a longer period than 12 consecutive hours; nor to be on duty for more than 14 out of any 24 hours; and every train employee must be relieved of duty for a period of at least 8 *consecutive* hours out of every 24 fours.

B. Before actually commencing duty, every train employee must sign a declaration that he has actually had sufficient sleep during the preceding 24 hours to prevent the possibility of his sleeping or being incapacitated by fatigue while on his run; and every employee who signs such a declaration falsely, shall be guilty of a misdemeanor. (The obstacles in the way of enforcing such a rule as this, would be almost insurmountable. The object of the rule is to prevent an engineer who may have spent his lay-over at his society lodge, or in nursing his sick wife or child, from going out on his run in such a

condition that he might sleep at his post. Sympathy for the man in trouble should not be permitted to endanger a hundred lives).

C. No employee having the right to govern the movement of trains by telegraph, or who, as operator, sends or receives messages giving train orders, may be permitted to be on duty for more than 8 consecutive hours, nor for more than 12 in any 24 hours.

D. No meeting or passing points for trains where either train is obliged to leave the main track, shall be made except at places having a telegraph office and an operator on duty.

E. A train having arrived at a point at which it is to meet an extra or irregular train, or more than one train or section of a train of any kind, may not proceed until it has received a written clearance from the operator at the point of meeting.

F. When it becomes necessary to run a train between the different sections of another train, the sections which run behind the interposed train shall lose their designations as sections of the original train, and shall be run as specials or as sections of some other regular train whose time they may have fallen back to. That is, under all circumstances, all trains which are designated by the same number must be kept immediately together.

The violation of any train rule should be punishable by law; and if such violation results in accident causing death, the violator should be held as guilty of manslaughter.

The taking of any risk, even though not specifically covered by rule, and even though not followed by accident, should be severely disciplined.

When such a device has been developed to the point of reliability, all road locomotives should be equipped with head-lights capable of throwing a strong vertical ray. This might, in some cases, prevent collision at night—the vertical ray being discernible* where curves or other obstructions would prevent an ordinary headlight being seen.

I will venture to touch upon one other subject which may seem to be concerned wholly with the economy of operation, but which I shall endeavor to show, has a material bearing on comparative safety.

It is self-evident that so long as every train is exactly on time, a collision is impossible. It is equally evident that as trains depart from their schedule, and special orders become necesary, the possibility of collisions enters as a factor, which increases in value as the train

* It is of course understood that practically all roads require that the head light be covered when the engine is standing on a siding, thus avoiding any doubt whether the opposing train is or is not occupying the main track. The same rule, of course, would govern the vertical ray.

movements become more irregular. It therefore follows that any practice which tends to disorganize the regularity of train movement is an element of danger, and should be corrected.

Perhaps the most ordinary cause of throwing a whole division off its schedule is the breaking in two or stalling of freight trains, or their general inability to maintain time, and this largely arises from the devotion of too much zeal to the accomplishment of one idea.

Under the old-school railroad man, railroading was not a science. The operating department got cars over the road, and did not concern itself particularly with the cost of doing it. It was the rule-of-thumb method of the so-called practical man. A few years ago, theory, which had so long been held in contempt, entered the field. Some thoughtful man realized that engines and crews were being run without much regard to the effective work accomplished; and the economic principle of "tons per train mile" became the most talked-of thing in railway operation.

Now, a period of transition is always fraught with danger, and when a lot of hard-headed, practical men become inoculated with a theory, their mental vision is apt to act like a search light which has become fixed in one position—illuminate one object, and engulf all else in darkness.

"Tons per train mile" became the one goal; and the superiority of a road or its manager was measured by its or his ability to haul more tons with one engine than could be done on a rival road.

This new fetish had good effect. It cut down grades, straightened curves, and stimulated a new line of thought. But it developed monstrosities in locomotives. It taxed each engine to its full, and frequently to more than its capacity. It put breaking strains on drawbars, increasing the liability of the breaking in two of trains. It decreased the speed of freight trains and rendered their stalling a more frequent occurrence. And all of this meant a disarrangement of the schedule in all branches of the service.

In calculating the power of an engine, it is not sufficient to consider simply cylinder area and steam pressure, but piston speed must also be included. The effectiveness of a machine is not measured by the work done, but by the work done in connection with the time required to do it.

"Tons per train mile" is an incomplete, and therefore comparatively valueless exponent of work accomplished.

An engine which hauls 1,000 tons over a division in five hours is manifestly a greater revenue producer than is an engine which takes

1,500 tons over the same division in fifteen hours; and yet the second engine has made the better showing on the "tons per train mile" exhibit.

"Ton miles per engine service hour" is the true measure of efficiency.

Every piece of machinery has, somewhere, an ideal point of highest efficiency, where the volume of work and the speed are in perfect equilibrium. An engine when working at materially under or over its normal load, is not being operated economically. Applying this law of physics to railway operation:—to send a locomotive over the road with one or two cars is a waste of energy which cannot be compensated by the great speed made possible; while to load a locomotive to its limit results in a waste of time which cannot be compensated by the volume of work done.

I believe that in many cases, if the load rating of engines were decreased from 10 per cent. to 20 per cent., the gross work accomplished would be greater, wear on men and equipment would be lessened, schedules would be more closely adhered to, and one element of danger would be eliminated.

SMELTERS AND SMELTING PRACTICE IN BRITISH COLUMBIA.

By William M. Brewer.

The growth and expansion of the mineral industries in British Columbia more than justify the importance attributed to them years ago in these pages, and supported by preceding articles by Mr. Brewer, Mr. Jacobs, and other authorities. The following article summarizes and brings up to date the progress made in the smelting installations of the province.—THE EDITORS.

THE history of the smelting industry in British Columbia really dates from 1888, when a small copper smelter was erected at Golden, a point on the Canadian Pacific Railroad at the confluence of the Columbia and Kicking Horse rivers. Apparently this smelter was erected only to secure a grant of land adjacent to the town, because after its completion it was never blown in. During 1889, the Kootenay Smelting and Trading Co. completed a smelting plant at Revelstoke, where the railway crosses the Columbia River about twenty-five miles northerly from the head of Arrow Lake, and commenced smelting lead ore on a commercial scale. Active operations were continued only for a short time. The works were then closed down, leaving a memento in the shape of a moulded bar of lead branded "Kootenay," which is now in the Mineral Museum in the Department of Mines at Victoria, where it is said to represent the first bar of lead smelted in British Columbia.

So far as can be learned, no other efforts were made to establish smelters in the province until 1891, when the site of the Pilot Bay smelter was chosen and construction work commenced. This smelter is on the shore of Kootenay Lake, about twenty miles east of the town of Nelson. Construction work was finished and the smelter put in operation early in 1895, during which year some three thousand tons of silver-lead bullion were shipped. Operations were suspended in the spring of 1896, because of the difficulty experienced in obtaining dry ores for fluxing purposes and also good coke and coal, and they have not since been resumed.

During the latter part of 1895, Mr. Paul Johnson, E. M., designed the silver-lead smelter at Nelson for an English company which owned the Silver King group of mines, about four miles in an air line from the smelter. With the completion of the construction of this

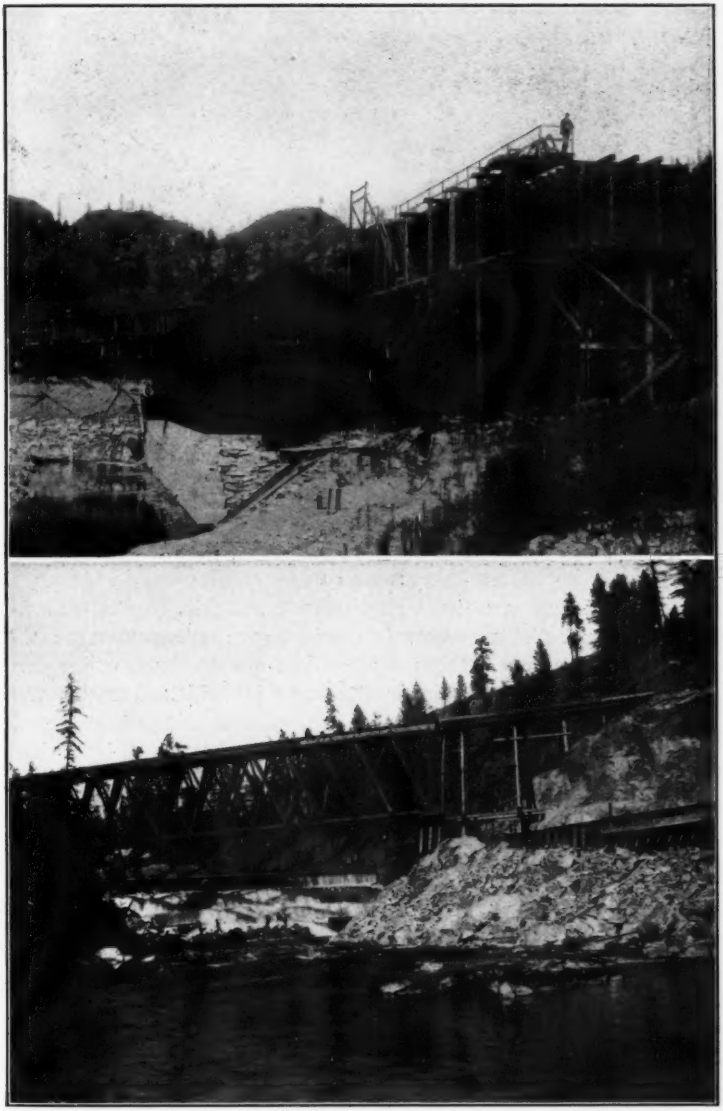
smelter, the actual history of smelting on a commercial basis in British Columbia may be said to have really commenced. This plant now consists of a sampling mill, two blast furnaces, one 40 by 100 inches and another 44 by 144 inches, one mechanical double hearth, straight-line roaster and three large hand roasters, and a well equipped laboratory and assay office. The air for the blast furnaces is supplied by two blowers driven by a 100-horse-power induction motor. The sampling mill is operated by a 50-horse-power induction motor. The blast

HALL MINES SMELTER, NELSON, BRITISH COLUMBIA.

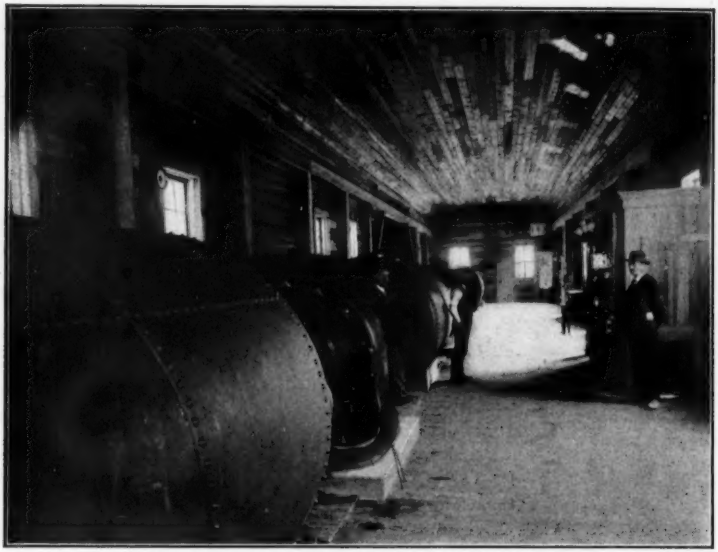
furnaces have a capacity of 180 to 200 tons of lead charge per day. The water jackets are of wrought steel. The slag is automatically removed by water granulation. The mechanical roaster is of the O'Hara type. The roasted product is mechanically conveyed to the briquette house, where it is automatically mixed with lime and passed through the briquetting machine, which forms it into bricks for charging into the blast furnaces. A complete machine shop is included in the plant.

Electric power is obtained from the hydro-electric power station of the West Kootenay Power and Light Co., at Bonnington Falls, distant about eleven miles west from Nelson, and is delivered at the smelter at 550 volts.

On Oct. 10, 1895, construction work was commenced on the smelter of the British Columbia Smelting and Refining Co., of which



PLANT OF THE GRANBY CONSOLIDATED MINING, SMELTING AND POWER CO.
The upper picture shows the power house, the lower the dam, at Grand Forks.



INTERIOR OF THE POWER HOUSE, GRANBY CONSOLIDATED MINING, SMELTING AND POWER CO.

Mr. F. A. Heinze of Butte, was president, with Mr. H. C. Bellinger superintendent. This smelter is situated at Trail, a point on the Columbia River distant about eight miles from Rossland, which during the early history of mining operations in British Columbia was the leading camp in the province. This smelter as originally designed, consisted of five furnaces—four reverberatories, hearths 14 by 22 feet, capacity 40 tons each per 24 hours, and one 40-inch circular furnace, 12 feet high to feed floor, water-jacketed, with six 3-inch tuyeres, also with fore-hearth. The capacity of furnace was 45 to 55 tons of ore per day.

This smelter was erected as the result of a contract made with the owners of the Le Roi mine to treat 75,000 tons of the gold-copper ore produced from that property. At the present time it is interesting to recall some of the terms of this contract, and compare the difference between the smelter rates, charged in 1896 and those of today. The rate for freight and treatment on the first 37,500 tons of this ore was fixed at $11.00 per ton, and the rate on the remainder to be the lowest rate obtainable on the open market. Having secured this contract, Mr. Heinze, previous to erecting the smelter and building a line of railway from Trail to Rossland, arranged for a land grant

from the provincial government, and a bonus from the Dominion Government of $1.00 per ton of ore smelted.

Until after the completion of the Boundary branch of the Canadian Pacific Railroad from Robson on the Columbia River to its western terminus at Midway, the Trail and Nelson smelters were the only two in operation in the province, the former treating principally the gold-copper ores of the Rossland district, together with any lead or dry silver ores obtainable, and the latter treating the silver-copper ore produced at the Silver King mine, together with any custom ores which could be secured. But since the day when these two smelters were able to meet the demand, there has been a vast change in the mining and smelting industries in the province. During the early days all the coke and coal consumed in the smelters came from the collieries on the east coast of Vancouver Island, and the cost for coke was about $12 per ton delivered. Since the completion of the Crow's Nest Pass branch of the Central Pacific Railroad, of course all fuel used on the mainland has been supplied from that field, at about half the cost price of the Vancouver Island fuel.

In 1898, Heinze sold his narrow-gauge railroad from Trail to Rossland and the Trail smelter to the Canadian Pacific Railroad, and that corporation, evidently anticipating a considerable extension of the mining industry as the natural result of the construction of extensions of their system, invested a vast sum in enlarging and improving the original plant, until today it has a capacity of 900 tons of copper ore and 400 tons of silver-lead ore, each 24 hours, while the lead refinery is capable of turning out 25 tons of pig lead per day.

The value of the entire plant when owned by Mr. Heinze was about $150,000, while the present plant is valued at approximately $1,000,000. The original plant gave employment to about 150 men, but today, when the entire plant is in operation, about 500 are employed. About 700 feet of side tracks were sufficient, in 1897, to meet the demands of the smelter; today there are nearly 3 miles required.

The motive power used in the original plant for running machinery was steam, and for handling ore between the bins, roast heaps, and the furnaces, manual labor; but after the completion of the Bonnington Falls power plant, arrangements were made for the transmission of electricity, the distance between the power plant and the smelter being about 30 miles. The line current is 20,000 volts, transformed to 550 volts at the smelter; it furnishes a total of 1,000 horse power in motors, divided into sixteen units. Of course steam has been abandoned since the installation of the electric plant, which has

also supplanted manual labor for pushing tram cars, and in every other department where it is possible.

The most recent improvement introduced into this plant is that of feeding the furnaces mechanically, instead of by hand. This is done by running cars containing the furnace charge on a track along the side of the furnace, and by a mechanical device, discharging the contents of each car into the furnace in such a manner that the charge is spread in a way very similar to that which prevails by hand feeding. The first mechanical feeders used in British Columbia were introduced at the Grand Forks smelter, but differed from the method employed at the Trail smelter, because at the former a track was laid across the furnace on a level with the charging floor, and bottom-dump cars were run on this track into the top of the furnace, the contents being dumped by means of a lever attached to the car in such a way that it could be handled from the outside of the furnace. So far as expedition is concerned, this method is probably a quicker means of charging the furnace than from cars at the side, but the advantage possessed by the method adopted at Trail is said to be that the charge is more evenly spread, and does not have any such deadening effect on the heat in the furnace as results from dumping the entire charge from the bottom of the car in one mass.

On the completion of the Boundary branch of the Canadian Pacific Railroad from the Columbia River west in 1899, the construction of the following three smelters—one at Grand Forks, by the Granby Consolidated Mining, Smelting, and Power Co., Ltd., of Montreal, Quebec; another at Greenwood, by the British Columbia Copper Co.; and the third at Boundary Falls, by a company which proposed to introduce pyritic smelting—was proceeded with almost simultaneously; the two first named were completed in 1900, the Grand Forks smelter being blown in on Aug. 21 of that year, but the Greenwood not until Feb. 17, 1901, while that at Boundary Falls, although completed, was never blown in as originally designed.

Metallurgists who had made a study of the conditions in the Boundary country recognized at once that, owing to the low grade of the ore, every economical device known to the designers of smelters would have to be employed in order to ensure profits; at the same time, owing to the phenomenal extent of these low-grade ore bodies, and the fact that, through the upper levels at least, the ore was not only oxidized but carried such percentages of iron, lime, and silica as to render it self-fluxing, the same metallurgists also recognized that the question of treating the ore successfully, from a commercial

standpoint, was not difficult to solve, provided smelter capacity proportionate to the producing capacity of the mines was installed. Consequently today we find in the Boundary country that the smelting capacity at Grand Forks is about 2,000 tons of ore per day; at Greenwood, between 700 and 800 tons of ore per day; and at Boundary Falls, about 900 tons of ore per day.

The Grand Forks plant comprises six double-decked, steel, water-jacketed blast furnaces, each 44 by 160 inches at the tuyeres, the furnaces arranged 39 feet apart, centre to centre; six Connersville blowers; two stands of converters, of the horizontal barrel type, with the capacity of 70 to 100 tons of matte daily; a 25-ton tilting furnace; a 40-ton electric travelling crane, 40-feet span, for handling the ladles of molten matte and the converter shells; 10-ton electric travelling crane, 24-feet span, for conveying the matte in ladles from the receivers at the furnaces to the tilting reverberatory; quartz crusher plant and grinding pan for mixing converter linings; fully equipped sampling mills, office, and laboratory.

The motive power employed is electricity, furnished through the water power developed by the company on the North Fork of Kettle River, which gives about 1,100 horse power. Besides this the smelting works are connected with the power system of the Cascade Water Power and Light Co., which is under contract to supply up to 1,000 horse power whenever required. Four double 16-inch turbine water-wheels, directly connected with alternating-current generators, comprise the generating plant. Except that steam power is employed at both the Greenwood and Boundary Falls smelters, and that at the latter no converter plant has yet been added—also that the two plants are of so much less capacity—the description of the plant at Grand Forks will serve for the others, so far as design of furnaces, machinery, and general arrangements are concerned. The slag at each of these plants is now hauled away and dumped hot, instead of being granulated, as was done as long as the dumpage facilities permitted.

Metallurgically considered, the ores of the Boundary district are the least difficult to smelt of any of the British Columbia ores, because there are absolutely no minerals or substances associated with these ores to render them difficult to treat. The ore being low in sulphur, no preparatory roasting is required, and up to the present time, no barren flux has been added to the charge. These conditions, added to the large capacity of the smelters, have led to the expression of opinions in the press that the cost for smelting in the Boundary district in British Columbia is unquestionably the cheapest extant. Any such

sweeping statement as this, is in my opinion, misleading, because while the results achieved in this direction in this district have been such as to cause metallurgists in other sections considerable surprise, yet when the high cost for labor and coke in British Columbia are compared with the low cost for labor and coke in Tennessee, and it is further considered that in the Boundary district cold blast is employed as against hot blast in Tennessee, by which the quantity of fuel is reduced from about 13 per cent. as used in British Columbia, to 3 per cent. in Tennessee, it seems to me that such a statement cannot be maintained successfully.

Earlier in this article I referred to the erection of the Boundary Falls smelter by a company which proposed to introduce pyritic smelting into British Columbia, and stated that as originally designed, the plant was not operated. While these are facts, yet if it were not explained that the plant was purchased in 1902 from the original owners by the Montreal and Boston Copper Co., by whom it was remodelled, and enlarged from the small capacity for which it was originally designed, to its present capacity of nearly 1,000 tons of ore per day, the later references to this plant would be almost unintelligible.

Some idea of the smelting capacity of such a plant as that of the Granby Consolidated Mining, Smelting, and Power Co., Ltd., at Grand Forks, may be gathered from the facts set forth in the following statement published by the British Columbia Government:

> "The tonnage of ore treated during less than four years to June 30 of the current year has been as follows: In 1900, (19 weeks) 62,387 tons; 1901, 230,928 tons; 1902, 312,340 tons; 1903, 401,921 tons; 1904, (26 weeks) 312,795 tons; total, 1,320,371 tons."

Dr. Albert R. Ledoux of New York is authority for the following statements with regard to the ores of the boundary district:—

> "The average ore of the best developed mine is said to contain 38 per cent. of silica, 16 per cent. of oxide of iron, 15 per cent. of lime, about 4½ per cent. of sulphur, 1.80 per cent. copper, besides gold and silver.
>
> "The upper ores are largely oxidized, and consist of massive magnetic iron ore, carrying copper sulphide and gold. This surface ore changes, at an average depth of perhaps 25 feet, to ore in which the iron is largely combined with sulphur, or sesquioxide, rather than in the higher oxidized form. By mixing these surface ores with those from lower levels, an ideal mixture is obtained, enabling the furnaces to produce directly a 45 per cent. to 50 per cent. copper matte, carrying practically all the gold and silver which the ore contains. On the north side of the Phoenix Ravine (where the mines of the Granby company are situated) the large amount of ore developed is estimated to run about 1.80 per cent. copper,

> $2.40 per ton in gold, and 25 cents per ton in silver. The workable ores from the south side of the Phoenix Ravine contain on an average copper 1.70 per cent., gold $1.60, silver 33 cents per ton. The ore from the easterly side of the main dyke dividing the Phoenix camp probably runs by the carload about 1.60 per cent. of copper, $1.50 in gold, and 30 cents in silver. The run of the mines in the Greenwood camp (where are situated the mines of the British Columbia Copper Co., and the Montreal and Boston Copper Co.) as shown by the smelter returns, is probably 1.60 per cent. copper, $1.80 in gold, and 50 cents silver. It may therefore be taken as a safe estimate that the very large amount of ore available in the Boundary district will vary from 25 pounds to 35 pounds of copper per ton of 2,000 pounds, with from 25 cents to 40 cents of silver, and from $1.50 to $2.50 in gold per ton."

I have not at hand further details with regard to the assay value of the boundary ores, but it is generally conceded that the values which they carried when Dr. Ledoux made his examination have remained about the same, nor has the character of the ore changed to any marked degree; and when the average analysis referred to by Dr. Ledoux is considered, it can readily be understood that neither of the smelter managers found himself confronted with any difficult metallurgical problem, other than that of bringing the cost down to the very lowest possible figure.

The fact that the Granby Company has paid dividends is proof positive that this feature has received the utmost consideration of the management; in fact, the government records show that in an affidavit returned to the assessor relative to the basis for taxation, the smelting costs are sworn to as being $1.76 per ton. It is quite unlikely that the cost for treatment at either of the other smelters will vary much from these figures. It is not stated in the affidavit, though, whether in this cost is included freight and selling costs of product in the New York market. If this cost is included, as it undoubtedly should be, then the actual cost for treatment falls below the figure quoted.

The metallurgists through whose efforts such gratifying results have been obtained are A. B. Hodges, in charge of the Granby Company's works, who also designed the plant; Paul Johnson, who designed and for a long time had charge of the British Columbia Company's works, and Albert I. Goodell, who remodeled and had charge of the smelting plant for the Montreal and Boston Copper Co.

Smelting operations have been carried on in the Coast District, which includes the adjacent islands situated in British territory, since 1899, when the 50-ton smelter erected by the Van Anda Gold and Copper Co., on Texada Island, was blown in on July 15. Between

that time and 1901, 17,543 tons of ore in all were treated at these works. Since then the smelter has not been operated, because it has been found to be more economical to ship the ore from the mines on Texada Island to the larger smelters on the east coast of Vancouver Island, which were erected in 1902.

The results achieved in this "baby" furnace during the time it was operated were particularly gratifying and successful, especially when all the surrounding circumstances were taken into consideration. Much of this success, however, is attributable to the character of ore treated. The great bulk of the ore was a high-grade bornite, which, although low in iron and sulphur contents, carried sufficient lime and silica for fluxing. The iron ore which was necessary to be added to the charge was supplied from deposits of magnetite occurring on Texada Island only a comparatively short distance from the smelter.

During the late fall of 1901, the production of ore from copper properties on Vancouver Island, especially on Mount Sicker in the southeastern portion of the island, attracted the attention of smelter men, with the result that a site was selected at Osborne Bay on the east coast, and the erection of the Crofton smelter by the Northwestern Smelting and Refining Co. was commenced. A few months later, the Tyee Copper Co., owners of the Tyee Mine on Mount Sicker, also erected a smelter in order to treat the product of their own mine. The Crofton smelter was established for custom work entirely, the company anticipating that it could be made a commercial success because a contract had been arranged for the entire product of the Lenora Mine, which adjoins the Tyee on the east; but owing to financial difficulties, in which the Lenora Mining Co. became involved, the mine was shut down in the fall of 1902, re-opened under a lease to the Northwestern Smelting Company in the spring of 1903, and again shut down during the spring of 1904, when the smelter also went out of blast and has not since resumed operations.

As a matter of fact, while the production of copper-gold ore in the coast district has been since 1901, and still is, sufficient to keep a 350-ton smelter in continuous operation, provided the entire production was shipped to one smelter, yet there has not been a sufficiently large production to warrant the operation of two smelters; and naturally, the one dependent on custom ore entirely would be the first to feel the consequences arising from a disregard of the law of supply and demand.

The Crofton smelter comprises three furnaces, the smallest being a 65-ton cupola for re-smelting matte, and the two larger ones water-

jacketed furnaces, with a capacity each of about 350 tons per day, one of these being known as the Garretson type of furnace; two converters, with an electric carriage for handling matte ladles, converter shells, etc.; a complete sampling mill, with a total height of 80 feet, and a capacity of about 1,000 tons per day; a 10 by 20 Blake crusher; and a completely equipped modern assay office. The works are operated by steam power. There are three 200-horse-power boilers; one condenser of 1,000 horse power; blowing engine, 16 by 36 by 42; power engine, 18 by 36 by 42; two Connersville blowers, one No. 8, and the other No. 5. The dust flue is 200 feet long, 10 feet wide, and 12 feet high; the expansion chamber where the dust finally settles is 24 feet by 40 feet and 20 feet high, and the circular brick smokestack is 120 feet high, the inside diameter of the shaft being 12 feet.

All the arrangements for receiving ore, either from Mount Sicker by the narrow-gauge railway, which connects that mining camp with the smelter, or by water from other portions of the island, province, and United States, are perfect and thoroughly up to date. In fact, this plant, in all its equipments, is one of the most modern in the west.

The Tyee Copper Company's smelter was erected at Ladysmith, on the east coast of Vancouver Island, in 1902. The site selected is between the Esquimault and Nanaimo Railway and Oyster Bay, having a water frontage of about 3,000 feet. Between the railroad and deep water, which is suitable for dock purposes, there is ample room for slag dumpage for years. The ground between high-water mark and the E. and N. Railway has been laid off in terrace form, which admits of a gravity system through the works. The plant consists of:—one water-jacketed furnace, 42 by 120 inches at the tuyeres, of which there are fourteen of 6 inches in diameter; two water-jacketed forehearths; 80-horse-power return tubular boiler; 14 by 36 Reynolds-Corliss engine; No. 7 Connersville blower; 17-horse-power engine for running a 200-light dynamo; complete ore and matte sampling plants, the former being equipped with Snyder automatic samplers; and a modernly equipped assay office. The capacity of this plant is about 250 tons of ore per day.

In connection with this smelter, several improvements have been designed by the management with regard to methods of handling ore at the roast heap yard, and also for preparing the "fines," of which there is a large percentage shipped from the mine, so that they can be charged into the furnace in the most desirable form.

The improvements in the roast yard consist in the following labor-saving devices:—first, movable bridge which spans the distance be-

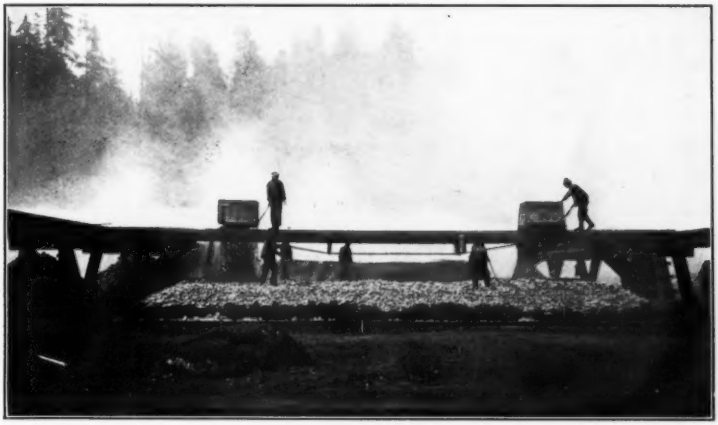
tween the trestles constructed along each side of the beds on which the ore is spread for open-air roasting or calcining; second, such an arrangement of the branch tramways over which the roasted ore is transported to the smelter, that although ore has to be shovelled from the roast heaps into the tramcar, it is all shovelled down because the level of the tram track between the roast heaps is so much lowered that the top of the car is at the same level as the floor of the bed on which the ore has been roasted

The movable bridge is built on wheels, and on a level 8 feet above the beds in the roast yard, so that it can be moved from bed to bed with ease; it spans the space between the permanent trestles, on which are laid the tracks from the bins in which the ore is received from the mine; the tram cars, loaded with raw ore and constructed for side dumping, are pushed from the receiving bins along the track to the bridge, switched onto it, and the car-sides are opened, allowing the ore to drop onto the bed from both sides of the bridge, while the car is in motion. So well has this automatic method of spreading the ore been found to work, that no shovelling is required except to level off the top of the heap when finished.

While in every other portion of the province where smelting operations have been carried on the metallurgical problems have been comparatively simple, yet the composition of the Mount Sicker ore is such that when the smelters were erected on Vancouver Island, the metallurgists engaged to manage them, viz., Mr. Thomas Kiddie for the Tyee Copper Co., and Mr. H. C. Bellinger for the Northwestern Smelting and Refining Co., were confronted with the solution of the following problem—the most satisfactory and economical practise to adopt for the treatment of burned ore of the following average analysis:—

	Per cent.
Iron	10.44
Zinc	8.14
Alumina	3.61
Barium Sulphate	34.08
Magnesia	trace
Lime	3.46
Silcia	22.51
Combined sulphur	7.42
Total sulphur	13.86

It is almost the only time that such a complex problem has presented itself in smelting practice, but after considerable experimenting the problem was solved by both the managers. Mr. Kiddie gives



MOVABLE BRIDGE, ROAST YARD, TYEE COPPER CO., LTD., LADYSMITH, VANCOUVER ISLAND.

the average analysis of the slags produced during the fiscal year ending May 1, 1904, as follows:—

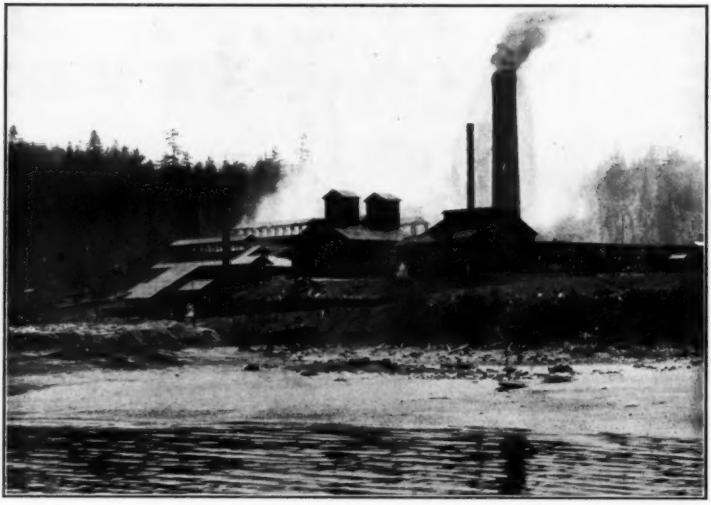
	Per cent.
Copper	.37
Iron	17.68
Silica	33.34
Alumina	10.75
Zinc oxide	6.44
Barium oxide	26.16
Calcium oxide	7.92

The data showing the analysis of the slags at the works of the Northwestern Smelting and Refining Co. not being obtainable at this time, there is no opportunity to compare the results.

Of course if a sufficient supply of custom ores suitable in composition for fluxing purposes could have been obtained regularly, the metallurgical problem would not have been as difficult to solve; but owing to lack of development in other camps on Vancouver Island, from which suitable fluxing ores could be drawn, the bulk of the ore which has been treated, both at the Ladysmith and Crofton smelters, has been this highly refractory Mount Sicker ore.

It is interesting to note the following taken from Mr. Kiddie's report to the Company under date April 29th, 1904:—

> "Answering yours of the 27 April, 1904, I herewith enclose a statement covering the smelter operations during the last six months; during this time the furnace was in blast 123 days of 24 hours each, an average of 20



SMELTING WORKS OF THE NORTHWESTERN SMELTING AND REFINING CO., CROFTON, VANCOUVER ISLAND.

days per month, and smelted 30,703 tons of material, of which 28,290 were ore, making a daily average of 249.6 of material, and 230 tons of ore per day, from which we shipped in the form of matte 2,275,997 pounds of copper, 72,207.8 ounces of silver, and 4,592.18 ounces of gold. A general analysis of the burned ore used during this period is as follows:

	Per cent.
Iron	11.45
Silica	19.36
Zinc	6.97
Barium Sulphate	38.87
Sulphur (in sulphides)	6.56

The general analysis of the slags produced during this period, which also includes custom ores, has been already given in this article.

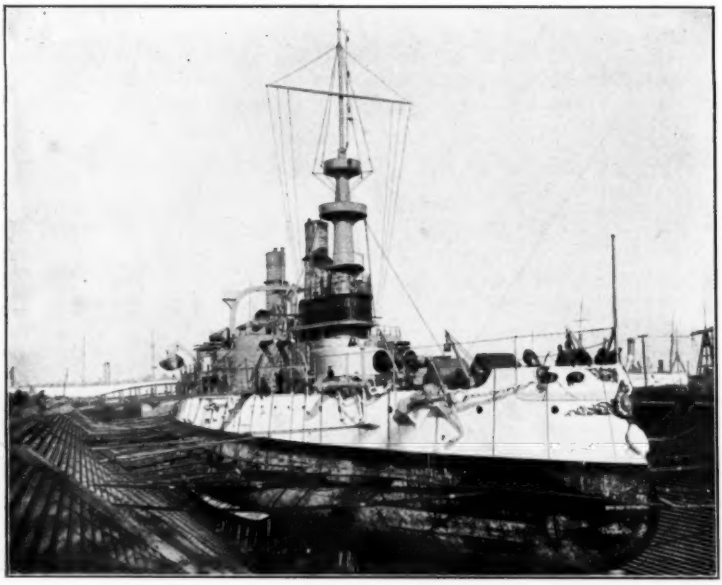
"The improvement in the slag assays for copper over the previous year is due in part to the increased settling capacity of the receivers at the furnace; in part to a reduction of the specific gravity in the slags caused by the admixture of suitable fluxing ores, which were not procurable in the earlier stages of our operations; in part to the lesser amount of zinc oxide in the slag, as a result of the admixture of other ores referred to; and in part to altered furnace practice, as a result of experiments with such ores. The specific gravity of the matte was between 4.7 and 5.0, and of the slags between 3.6 and 3.8.

"Of the total ore smelted 62.8 per cent. was burned ore, 22 per cent. raw sulphide ore, and 15.2 per cent. raw custom ore, or 62.8 per cent.

burned ore, and 37.2 per cent. raw ore, from which a shipping matte of from 40 per cent. to 45 per cent. copper was produced in one smelting operation. Comparing the furnace work of the past six months, as shown above, with the last annual statement, it will be seen that the capacity of the furnace has been raised from 177 tons per day to 249.6 tons, an average of 72.6 tons per day."

Another question that was a difficult one to solve at the Ladysmith smelter was the best means to adopt for charging the "fines" into the furnace. The high contents of sulphur carried by these fines made it imperative that they should be roasted. After experimenting, Mr. Kiddie ascertained that by mixing the fines with ordinary brick clay, in a pug mixing machine, then moulding the product into bricks of ordinary size, and drying on a floor heated with hot air, the result was a product which not only stood handling, but which, when roasted, proved to be a most satisfactory material to charge into the furnace. It was sufficiently hard, and carried such a percentage of silica as aided in fluxing. From a commercial standpoint it is demonstrated that it is more economical to make the fines into bricks and then roast, than to roast in mechanical furnaces, and afterwards briquette the roasted ore.

The fuel used in the Vancouver Island smelters is the product of the coke ovens at Union, Vancouver Island, owned by the Wellington Coal Co. This a 72-hour coke, physically hard and compact. The average analysis of a large quantity was as follows:—volatile hydrocarbon, 6.90 per cent.; fixed carbon, 68.64 per cent.; ash, 22.10 per cent.; and sulphur, 2.30 per cent. This coke is found to be well adapted for blast-furnace work, notwithstanding the high percentage of ash.



U. S. BATTLESHIP MASSACHUSETTS, DOCKED WITH EXTRAORDINARY RAPIDITY AFTER GROUNDING OFF THE MAINE COAST, IN 1903.

THE DEVELOPMENT OF DRY-DOCK PUMPING MACHINERY.

By Joseph S. Shultz, U. S. N.

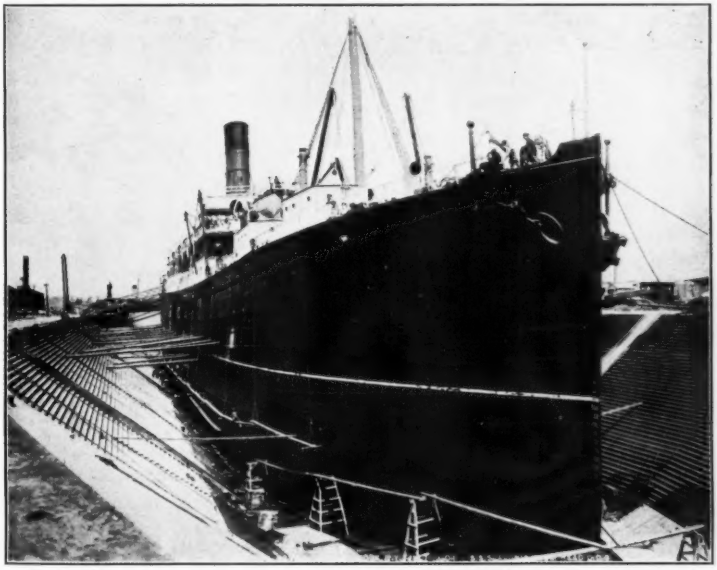
THE maintenance of the highest state of efficiency and of economic operation of all maritime craft, whether their purpose be war or commerce, is dependent primarily upon the means afforded for repairs. The recent tremendous development in the freight and passenger-carrying capacities of the transatlantic steamships was possible only after adequate dock-yard facilities had been established on both sides of the Atlantic; and no nation, however ambitious or whatever the necessity, can maintain a navy unless there be coincidently installed proper shops, docks, and manufacturing plants to overhaul and equip the vessels composing it. Perhaps never has this fact been more forcibly impressed upon the public generally than by the events immediately following the first encounter between the Russian and Japanese squadrons at Port Arthur, when, had there

been a carefully designed repairing plant available, the crippled Russian vessels could have been placed within a month in condition to do battle again—a circumstance which, with the aid of the Vladivostok ships, might have determined the control of the sea.

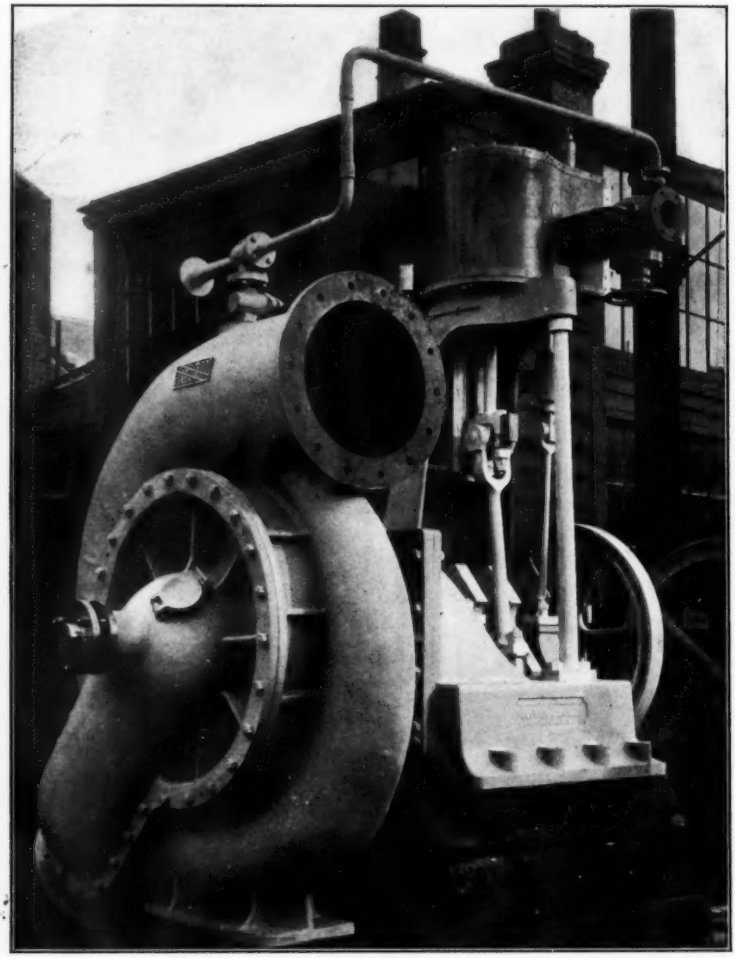
Essentially a ship-yard plant must consist of:—

1. Wharves or quay walls.
2. Traveling cranes.
3. Repair and manufacturing shops.
4. Storehouses for spare parts and equipment.
5. Dry docks.

The wharves or quay walls afford the necessary berthing space for vessels which have to undergo but slight alterations, such as replacing boiler or engine parts, painting, rearranging a portion of the interior, etc., the heavy pieces being transferred to and from the vessel by means of the cranes. Such repairs as these are most frequent, requiring but little suspension of the vessel's regular duties; but periodically—the intervals depending upon the character of the vessel and the service to which it has been subjected—there must be made a complete and thorough overhauling of the hull and equip-



CUNARD LINER SLAVONIA DOCKED IN THE NEW YORK NAVY YARD, JULY, 1904, ON ACCOUNT OF LACK OF FACILITIES IN PRIVATE YARDS.

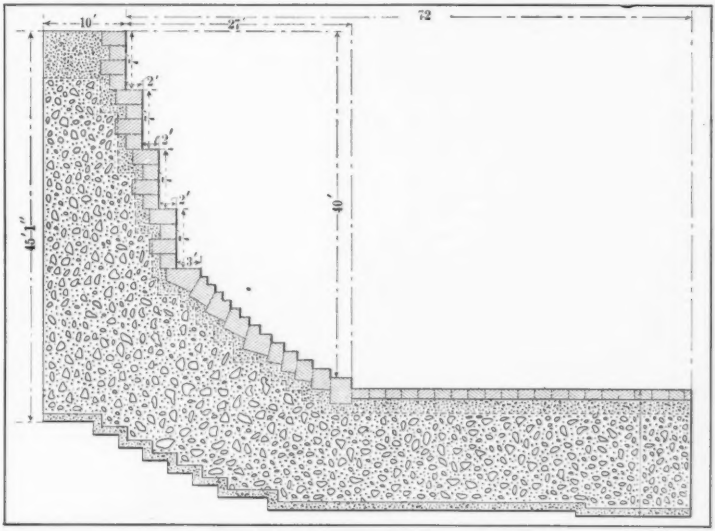


24-INCH CENTRIFUGAL PUMPING ENGINE, CAPACITY 3,000 TONS OF WATER AN HOUR, FOR A GRAVING DOCK IN THE NORTH OF ENGLAND.

Pulsometer Engineering Co., Ltd., Reading. The propeller is 40 inches diameter; specially designed blades for low-lift work. Engine of high-speed type, 16 by 20, with crank-arm balances forged in one of the crank shafts.

ment. This can be done only by placing the vessel in dock, where, by the removal of all the water surrounding it, the entire vessel is exposed and every portion may be thoroughly examined.

In addition to this periodic docking for general renovation, the same course must be followed in case of any accident causing injury to the hull below the water-line, and whenever the steering gear, shafts, or propellers may require attention. Consequently, although all of the five classes of dock-yard accessories are absolutely essential, it is obvious that the dry dock is really the most important of all; and, inasmuch as the water within the dock must be removed at least twice for every docking of a vessel, it is also evident that the pumping machinery plays a part of no small moment in the operation of the complete plant.

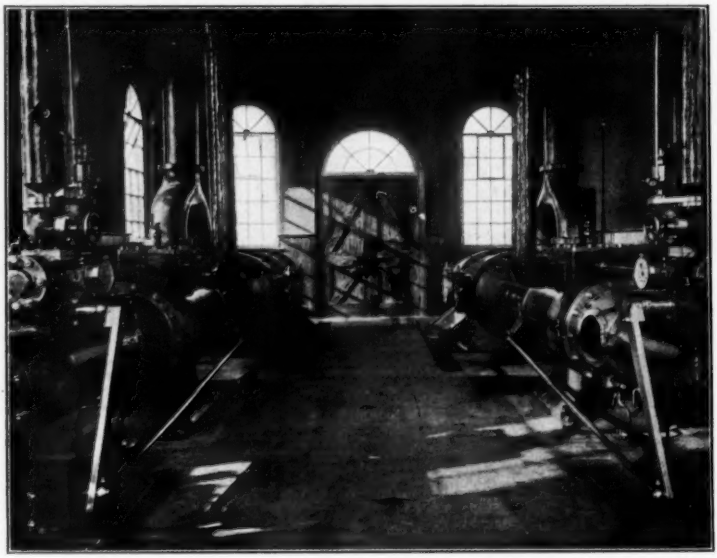


CROSS-SECTION OF ONE-HALF OF A GRAVING DOCK.

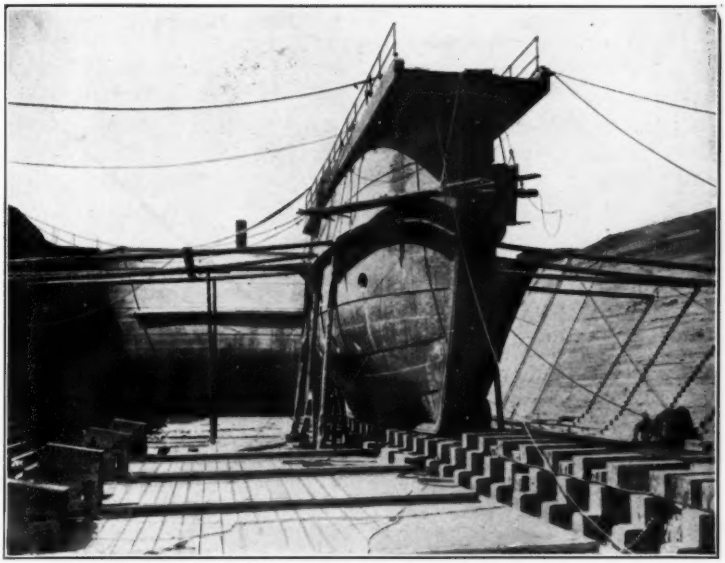
The following description of the salient features of the dock proper will aid in explaining the duties required of dry-dock pumps and the considerations governing their design.

Of the dry docks in use at the present time, there are two classes—floating and graving. The former is indispensable under certain conditions and of growing importance generally, but there are rather a small number in commission compared with the graving type, of which there are probably six hundred, ranging in value from $100,000 to $4,000,000. In general, the same kind of machinery is employed for each, but attention will be given here only to that pertaining to the graving type.

A graving dock is an excavation made to a certain depth below mean low water, lined so as to be made as nearly waterproof as possible with timber, stone, or concrete, and closed at the entrance end by a removable gate or caisson. The section is essentially U shaped, conforming to the lines of the largest vessel to be docked, with about 25 feet clearance on both sides to afford ample space and light under and around the hull. A section that may be taken as typical of graving docks is given in the illustration on the preceding page. In this basin is set a central line of keel blocks. These sustain the major part of the weight of the vessel, are spaced about 4 feet on centers, and are composed of square blocks of oak built to a height of 6 feet. On each side and distant 12 or 15 feet from the center is a line of blocks termed the docking keel blocks, inasmuch as they support the vessel near its docking keels. The tops of all of these blocks must be adjusted to fit the keel of each vessel, which necessitates the removal of all the water preliminary to every docking. Bilge blocks, sliding on racks, and spaced approximately 18 feet center to center, afford the necessary steadying power applied to the sides to keep the vessel from overturning. These are curved on their top surface to fit the hull and are



PAIR OF DAVIDSON COMPOUND ENGINES FOR HANDLING 300,000 GALLONS PER HOUR. Made for canal dock service on the Manchester ship canal by W. H. Bailey & Co., Ltd., Salford.

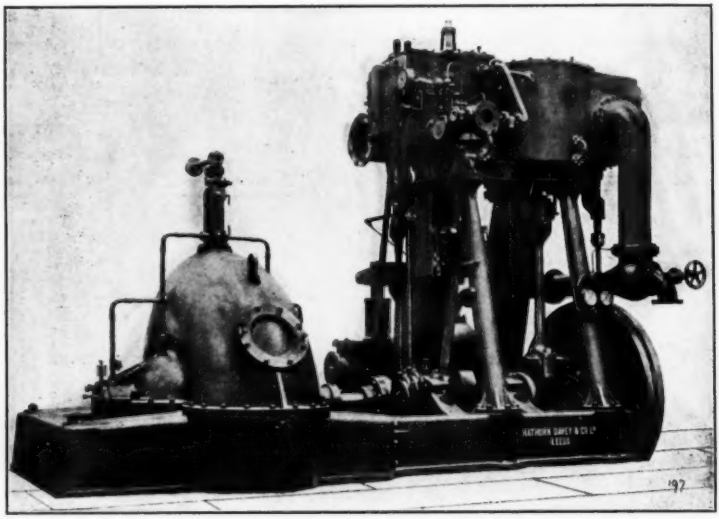


A DRY-DOCK CAISSON, DOCKED FOR EXAMINATION.

Another caisson, in position at the dock entrance, is seen in the background.

drawn in tight against the vessel by means of chains and pulleys just after it has settled on the keel blocks.

Various expedients have been employed for closing the entrance of the dock—automatic lifting gates, and double steel gates, and a single one hinged at the bottom after the fashion of similar ones used on canal locks—all of which have given way to the caisson in docks where the clearance over the entrance sill exceeds 25 feet, owing to the tremendous pressure existing and the consequent heavy construction made necessary with the above depth and a required corresponding span of over 100 feet. The caisson is a carefully designed boat with a keel on the bottom and the two ends, which rests in a groove in the dock, affording the requisite means for transferring the water pressure to the abutments of the dock and for making an absolutely water-tight closure. Through the caisson are perhaps a dozen or eighteen culverts, closed by valves, through which water is admitted to the dock when it is desired to flood it, and two inlets to the hold of the caisson itself through which water is drawn to provide the ballast required for sinking it in place in the grooves. The illustration above gives a view of a typical structure of this kind.



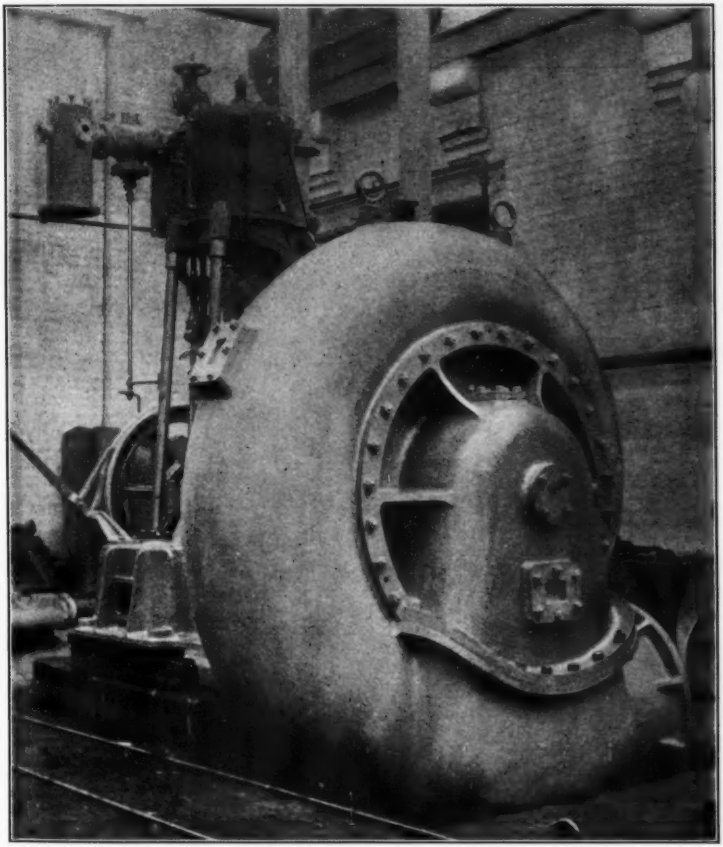
INVERTED, VERTICAL, COMPOUND, JET-CONDENSING PUMPING ENGINE WITH CENTRIFUGAL PUMP, SUITABLE FOR DRY-DOCK WORK.

Cylinders 18 and 32 inches diameter, 2 feet stroke; capable of raising 140 tons of water per minute to a height of 13 feet. By Hathorn, Davey & Co., Ltd., Leeds.

A culvert, fitted at the entrance with a rather coarse screen, so as to exclude large pieces of wood, ropes' ends, etc., conveys the water from the bottom of the dock to the well where the pumps are located. The earliest graving docks depended upon the tides for removing the water, the vessels being placed in dock during the highest spring tides; but an exception is the one described by Ptolemy, used by the Greeks in A. D., 220, which was equipped with pumping engines—he leaves us uninformed, however, as to what class of engines was employed.

It was not, however, until the eighteenth century, when the English began to strengthen their navy so materially, that graving docks of the modern type were built to any extent. In fact, the slow and expensive means theretofore employed for handling water greatly retarded development in both mining and ship-building; and, though the necessities of the former industry led directly to the invention of the steam engine, the immediate design of steam pumping engines for graving dry docks would indicate that this use, if not an actual incentive to the invention, afforded so ready and pertinent an application of the principle as to influence greatly much of the subsequent development of this new motive power.

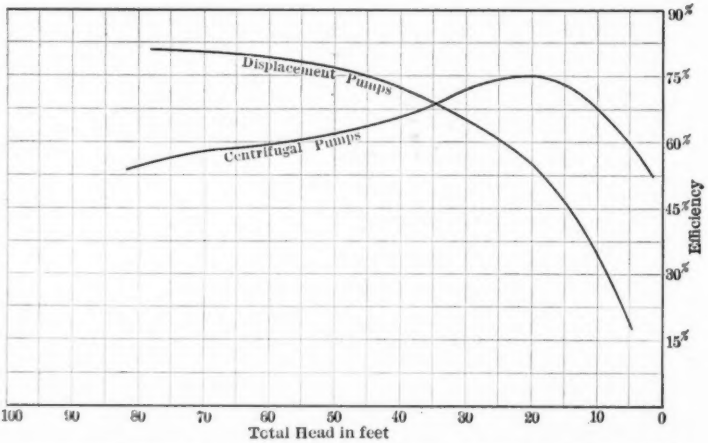
From the above time, steam-driven displacement pumps were universally used for removing the water in dry docks until about 1865, and even now some of the latest installations have been of this type—the largest, probably, being those in the Portsmouth, England, dock yard. These have plungers 72 inches in diameter with a corresponding length of stroke, are driven by compound vertical engines with cylinders 64 and 40 inches in diameter, and have a capacity of 70,000 gallons per minute with 875 indicated horse power.



ONE OF THE TWO 36-INCH VERTICAL CENTRIFUGAL PUMPING ENGINES CONSTITUTING THE PUMPING PLANT OF THE PRINCE OF WALES DOCK, SWANSEA.

Drysdale & Co., Bon Accord Engine Works, Glasgow. The plant raises 1,000,000 cubic feet of water in about 2 hours on a lift of 16 feet.

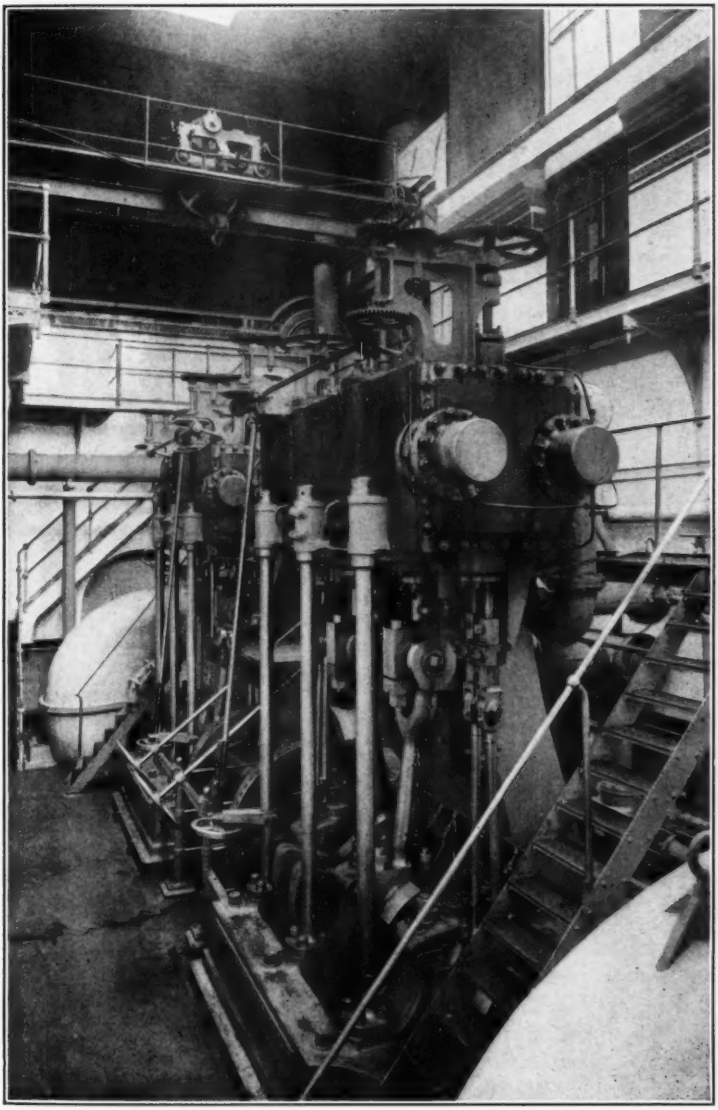
Just below there is shown a curve giving the variation in efficiency of reciprocating pumps—the abscissas being the total head in feet, and the ordinates the ratio between the water horse power (the actual water pumped) and the indicated horse power. Another curve constructed in a similar manner gives corresponding data in regard to single-stage or volute centrifugal pumps—greater efficiencies with the higher lifts being obtainable by the use of the turbine type of centrifugal pumps, or by a multiple-stage type, in which cases water can be handled very efficiently up to heads of 2,000 feet, but with comparatively small discharges.



COMPARATIVE EFFICIENCY CURVES OF CENTRIFUGAL AND DISPLACEMENT PUMPS.

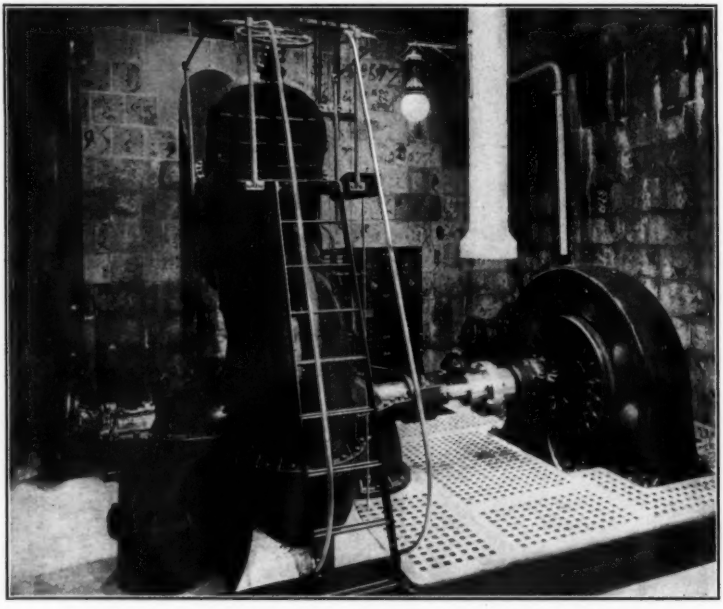
In no modern graving dock does the depth of water over the entrance sill exceed 35 feet at mean high tide, and most docks of this kind, owing to the greatly increased cost due to the heavier construction made necessary by the excessive pressure, have but 31-feet clearance, and the bottom of the main body of the dock is usually only 5 feet below the sill. Therefore the total head on the pumps for dry-dock work never exceeds 40 feet, and is in most cases less; owing, however, to the shape of the dock section in general use, from two-thirds to three-fourths of the water contained in the dock is included in the portion whose depth below mean high water is one-half (usually 17 feet) of the total depth.

With these facts in mind, it is at once evident from an examination of the above curves why the centrifugal pump has now almost universally supplanted the displacement type for this class of work.



PUMPING MACHINERY FOR NO. 3 GRAVING DOCK, CLYDE NAVIGATION TRUST.
Andrew Barday, Sons & Co., Ltd., Kilmarnock, Scotland.

Although invented in 1818 in America, it was not until half a century later that the combined skill of American and foreign engineers had produced a perfectly satisfactory centrifugal pump; but since then it has been used at low heads for lifting not only water, but mud, sand, and sewage as well.



THE FIRST ELECTRIC-DRIVEN DRY-DOCK PUMP IN THE ORIENT.

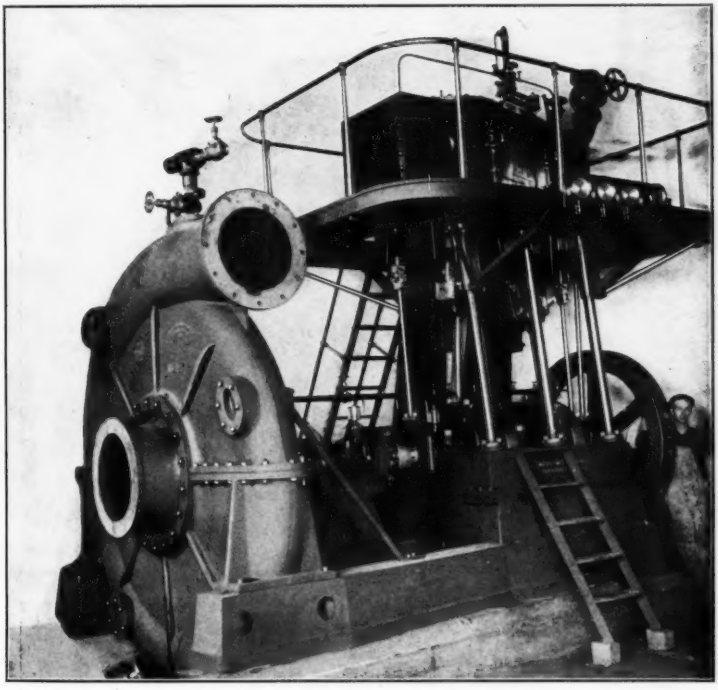
30-inch double-suction pump, direct-connected to 250-horse-power 220-volt General Electric direct-current motor. Installed at the Kowasaki dockyard, Kobe, Japan, by the American Trading Co., 1901. Built by the Lawrence Machine Co., Lawrence, Mass.

A striking illustration of the economy of this class of pumps may be had from the fact that for a capacity equal to that of the Portsmouth pumps referred to previously, and with the same head under which they operate, a centrifugal pump would use only 580 indicated horse power, against the 875 required for the reciprocating type.

It was not, however, consideration for economy alone that brought about the adoption of centrifugal pumps for dry-dock work. Their first cost is less, and owing to their simple construction they require less expenditure for repairs to moving parts and are less affected by the corrosive action of sea water. In addition to these there are three other important points of superiority:

First.—The circular motion and exact balancing attainable eliminate all the vibration of displacement pumps, which is particularly harmful both to the masonry of which the pump well is constructed and that of the dry dock proper as well.

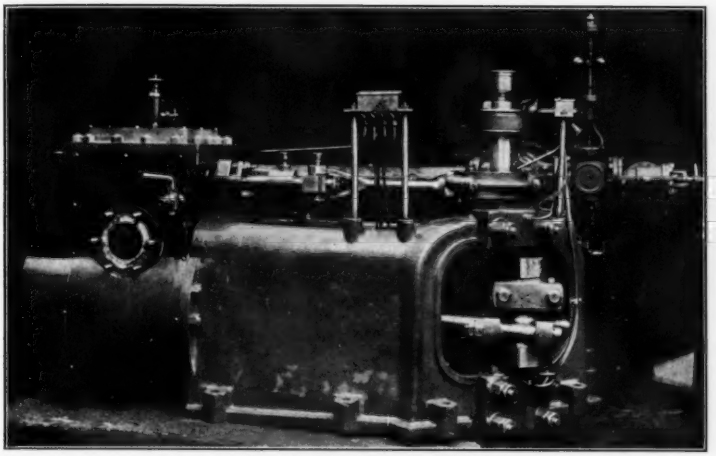
Second.—In locations where great difficulty is experienced in regard to water leakage, the engines or electric motors can be placed above the water level and connected to the pumps below in a separate chamber by vertical shafts, as was done by the Newport News Ship Building Co. in their new pumps which handle 150,000 gallons each per minute.



CENTRIFUGAL PUMP DIRECT-CONNECTED TO 10 BY 10-INCH DOUBLE ENGINE.
Morris Machine Works, Baldwinsville, N. Y.

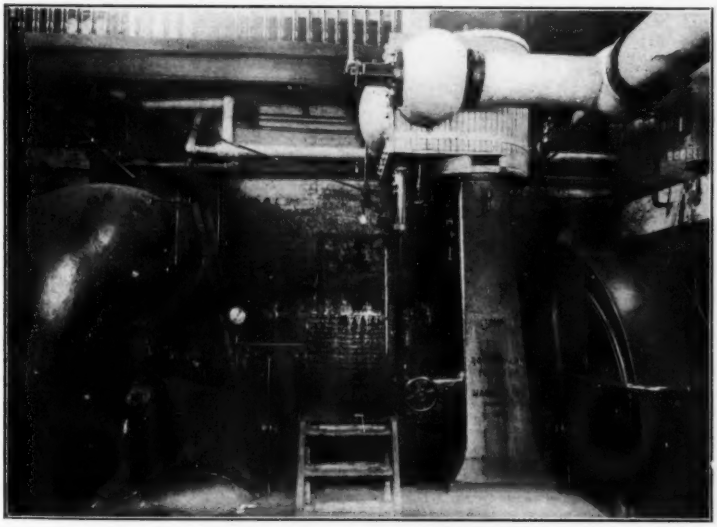
Third.—The water in a dry dock always contains more or less scrapings, chips, and other rather large refuse, which will readily pass through the large water passages of the centrifugal pump, but would be caught by and clog the valves of the displacement pump.

DRY-DOCK PUMPING MACHINERY FOR DEALING WITH 250,000 GALLONS PER HOUR.
W. H. Bailey & Co., Ltd., Salford.



ONE OF FOUR SETS OF COMPOUND ENGINES FOR DRIVING THE PUMPS OF NO. 2 FLOATING DOCK, DURBAN.

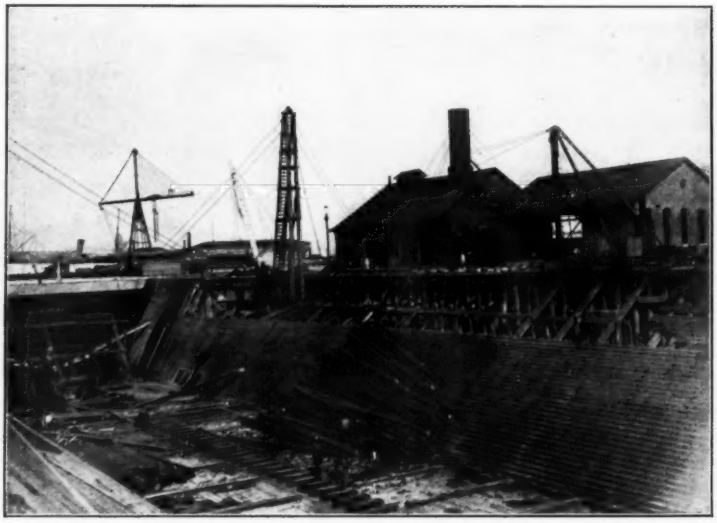
The pumps are placed horizontally at the bottom and driven by vertical shafting with ball bearings and flexible couplings. Drysdale & Co., Glasgow.



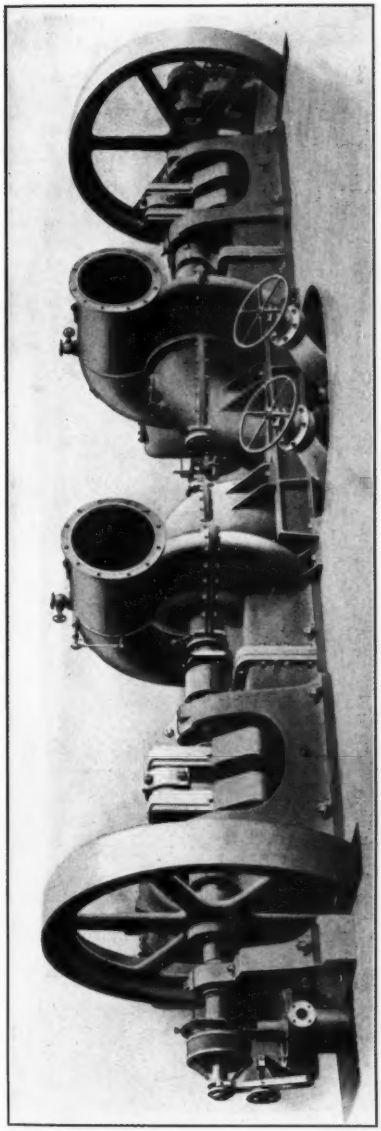
CENTRIFUGAL PUMP DRIVEN BY A DIRECT-CONNECTED VERTICAL ENGINE.

Southwark Foundry & Machine Co.

Until 1900 nearly all dry-dock pumps were steam-driven. Since then most of the new installations have been equipped with electric motors. The pump well must be located at or near the entrance of the dock, in order to make the lengths of the suction and delivery pipes as short as possible, since these are costly to install and greatly increase the friction losses. The engines and piping in a steam plant occupy a great deal more space than do electric motors, thereby increasing the size of the pump house, which area, together with that taken by the boilers and coal bins (which must be installed immediately adjacent) is probably never less than 5,000 square feet. This was the main consideration bringing about the change from steam to electricity, for with the latter the pumps and motors can be located wholly below the coping level of the dock, and the entire area occupied by the steam plant, which is the most valuable in the ship-yard, will be available for the necessary operations involved in the repairs to a ship in dock. The pertinence of this statement is amply verified by reference to the photograph below, showing the pumping plant at the United States Navy Yard, New York, which will be completely abandoned for the underground electric installation to be more fully described subsequently.

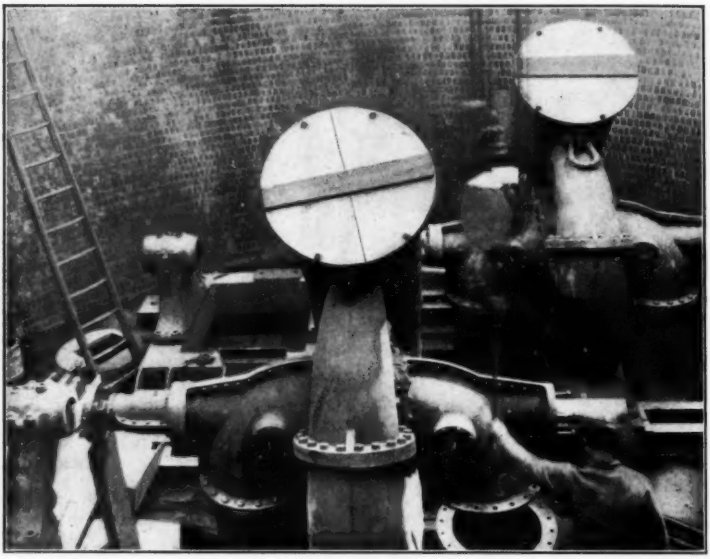


THE STEAM PUMPING PLANT AT THE NEW YORK NAVY YARD. REPLACED BY NEW PLANT DRIVEN BY INDUCTION MOTORS.

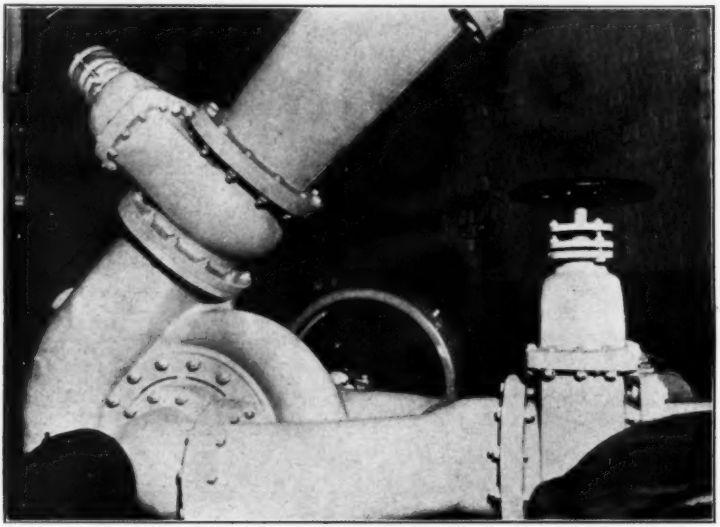


TWO 26-INCH CENTRIFUGAL PUMPS DIRECT-DRIVEN BY 125-HORSE-POWER GAS ENGINES.
Made for the Swansea Harbour Trust by Tangyes, Ltd., Birmingham.

The advisability may be questioned of apparently sacrificing the energy lost in the added operation of generating the electric current; but here there is also economy, instead of waste. The power for operating dry-dock pumping machinery must be always available for immediate use to dock or undock vessels under unforeseen or pressing circumstances. Hence steam must be kept up continuously in either case; but, if the boilers and dynamos are located in the central power house, the power for the pumps can be devoted to other purposes during the times of inactivity, and when pumping out the dock, which requires but two hours, these operations can be temporarily suspended. This use of the dry-dock power for the major part of the time without the expense of initial installation, and other savings incident, are greatly in excess of the value of the energy absorbed by the dynamos and the motors.



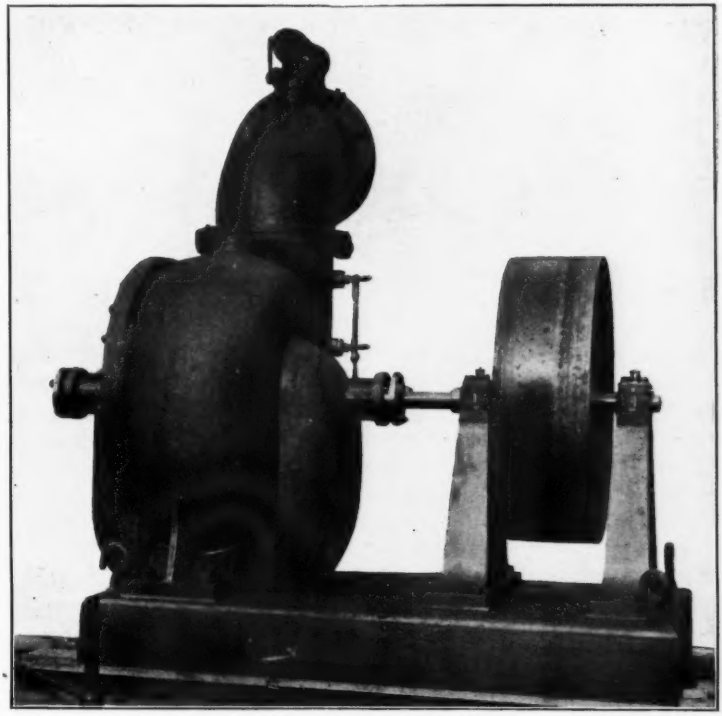
CENTRIFUGAL PUMPS FOR OLD GRANITE DRY DOCK, NEW YORK NAVY YARD; VIEW TAKEN DURING CONSTRUCTION.



CENTRIFUGAL DRY-DOCK PUMP DRIVEN BY A DIRECT-CURRENT MOTOR.

Of necessity the central power plant must be located as near the center of gravity of the loads as may be, and very frequently this makes the lengths of the circuits to the pump wells rather long.

For low-voltage direct current, which is the system in use in commercial ship-yards in America and for naval yards as well in Europe, it has been found that, to provide the necessary copper for the large current transmitted, without undue heating, the area of the conductors must be made very large and this is of course very expensive. It was due to this fact and to the great simplicity of alternating apparatus, that high-voltage alternating current was selected for the motive power for the new pumping plants at the Algiers, Mare Island, Boston, and New York Navy Yards. These installations represent the highest development in dry-dock



ONE OF A NUMBER OF LARGE CENTRIFUGAL PUMPS SUPPLIED TO EGYPT. RAISES 50 TONS OF WATER A MINUTE.

Clayton & Shuttleworth, Lincoln, England.

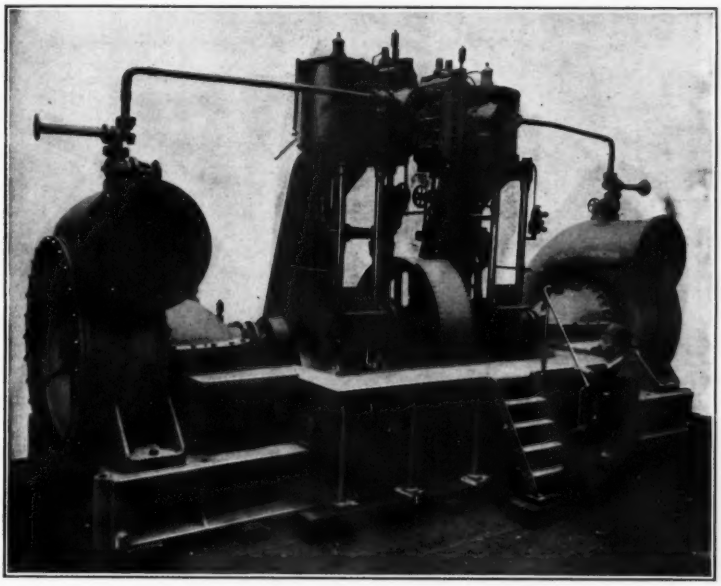
pumping practice, and are but further examples of that progressive spirit that has dominated the American Navy to make it the world's criterion for efficiency and effectiveness.

At the New York Navy Yard the new pumping plant serves to drain two parallel dry docks 350 and 625 feet long, and is located between them in a well 30 feet deep and 45 feet in diameter, which is perfectly water-tight and roofed over with a heavy concrete-steel construction, built level with the dock coping. Three 42-inch, horizontal-shaft, centrifugal pumps of 50,000 gallons each per minute, interconnected to each dock through motor-controlled valves, are the primary units of the plant; while two 16-inch pumps of the same type serve to dispose of any leakage while the docks are empty. The priming of these pumps is accomplished by means of a 10-horse-power motor driving a 12-inch by 12-inch air pump connected to the tops of the volutes. The motive power is furnished by three 415-horse-power induction motors, direct-coupled to the shafts of the large pumps, and each of the smaller pumps is driven by a 125-horse-power motor of the same class. These motors are of the three-phase type and operate on a 60-cycle, 2,000-volt, alternating-current circuit. The large ones have 42 poles each and the small ones 34, and the rotating field is produced by impressing the electromotive force of 2,300 volts on the windings of the stationary part or stator—the secondary part being the rotor connected directly to the pump shaft.

The difficulty with all induction motors—and the determining factor against their universally supplanting the cumbersome direct-current machines—is the fact that their speed can be varied with efficiency through only very narrow limits, greater reduction of their rated speeds being attainable but with little or no diminution in the current actually consumed by the motor and controlling apparatus. Now, in a centrifugal pump, the advantageous velocity varies directly with the head pumped against and is expressed by the formula:—

$$u = \frac{a\ g\ H}{Q}$$

in which u is the velocity of the outer circumference of the impeller; a, the area of the discharge pipe; H, the actual head plus the friction head; Q, the discharge, and g, the acceleration due to gravity. It would seem, therefore, since the speed of the above motors cannot be economically reduced, that this type is not desirable for dock pumps. But the conditions peculiar to the work of dry docks alter this. When a vessel is to be docked, the water must be removed with the least possible delay; for even a slight loss of time in the docking of one of the



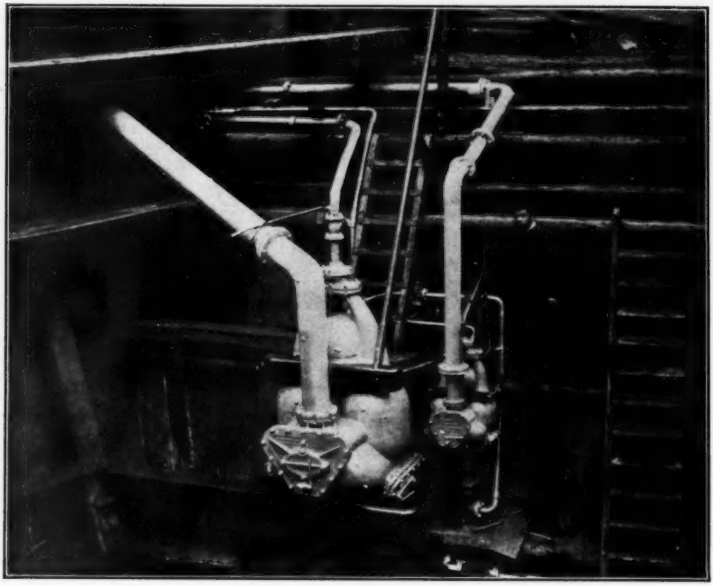
PAIR OF 21 BY 18-INCH ENGINES AND 30-INCH CENTRIFUGAL PUMPS, FOR A DOCK AT NAGASAKI, JAPAN.

Supplied to Stockton & Co. by Tangyes, Ltd., Birmingham.

giant transatlantic cruisers might result in its total loss, together with the immense capital invested, and of what vital importance would every moment be withdrawing one of our battleships from a defending squadron in case of war!

The pumps and motors were therefore designed for a rated speed corresponding to a head of 17 feet, within which head is included three-fourths of the entire amount of water in the docks. The pumps are started and maintained at this velocity, thereby obtaining a greater discharge during the first part of the pumping down to 17 feet (which is the major part) and the efficiency lost in the increased discharge is far less than that lost in attempting to control the speed—and in addition, there is the actual money value of the ultimate saving of time resulting.

The current for these motors is supplied by means of a turbo-alternating unit of the three-phase, 60-cycle type, designed to run at 1,800 revolutions per minute and at a primary voltage of 2,300 volts. It is capable of running continuously at 50 per cent. overload for two hours



TWO PULSOMETERS WORKING IN A DRY DOCK IN THE NORTH OF ENGLAND.

without injurious mechanical or electrical strain, and with a temperature rise of not more than 60 degrees C. above that of the surrounding atmosphere. It can also be momentarily overloaded 100 per cent. without harmful effects. At full load this unit consumes 20.5 pounds of dry steam per kilowatt hour, if operated condensing with 2 inches of absolute back pressure in the condenser.

The distance between the generator and the pumpwell is 1,350 feet, and in the circuits supplying this alternating current an actual saving of $31,000 is made above the cost of the conductors required for transmitting the requisite amount of direct current.

Though differing slightly in details from the above, the plants at Algiers, Mare Island and Boston are similar in principle; and, when all are completed, the dry-dock pumping equipment at these yards will be such as to afford the readiest and most efficient means for repairs, thereby adding untold strength and effectiveness to the vessels of the navy dependent upon them.

FIG. I. THE DAM AND INTAKE.

A GRAVITY CEMENT MILL IN THE PYRENEES.

By Geo. M. Peek.

Mr. Peek's article (like that by Mr. Burns, which directly follows it) is particularly interesting in that it shows how the resources of countries which are in their industrial infancy are being developed by the engineering talent and the machinery builders of the more progressive nations. Mr. Peek, like Mr. Burns, was in direct charge of the work he describes.—THE EDITORS.

THE Compañia General de Asfaltos y Portland was organized in Barcelona in 1901, for the purpose of acquiring and developing mines, quarries, and water power. In the Province of Cataluña near the little village of Pobla de Lillet, about one hundred and thirty-six kilometers from Barcelona, the company encountered an abundance of cement, or argillaceous rock, limestone, gypsum. and coal, being all the ingredients required for the manufacture of Portland cement. In addition to this, they found that the Llobregat River, which runs by the stone quarries, would give them an effective head of about one thousand feet and ample water for the development of sufficient power for turning out 1,000 barrels of cement per day.

After making a careful investigation of machinery manufactured in the different countries of Europe and the United States, they concluded that the best place in which to buy such machinery was the United States, and consequently the order for the machinery for the

complete plant was placed there. The location of the quarries was such that the company could build what might be called a gravity cement mill, and save the expense and power otherwise needed for elevators.

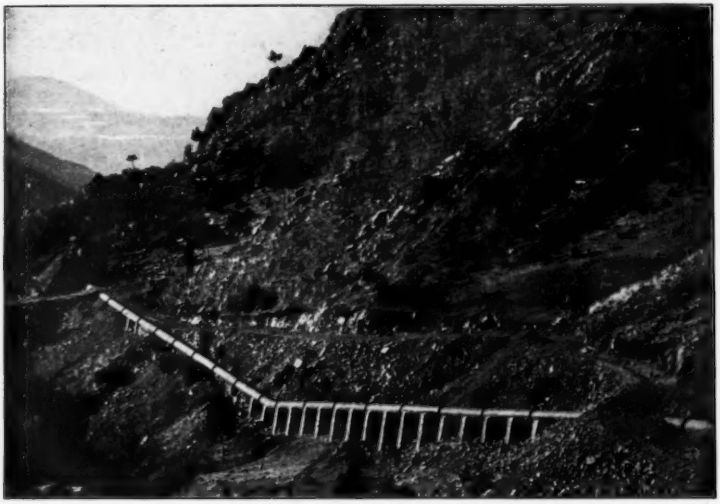


FIG. 2. THE PIPE LINE ENTERING THE TUNNEL.

I was sent over to Spain to make the survey and locate the pipe line. The source of the Llobregat River is a large spring, in the foot hills of the Pyrenees Mountains, which has a flow of 300 to 1,200 litres of water per second. Just below this spring it was decided to build the dam and intake for the pipe line. Figure 1 shows the dam and intake, with gates and gate-keeper's room and telephone station. From the level of the dam to the lowest level in the mill there is a fall of 1,049 feet. The pipe line from the intake to the last section in the mill is 14,935 feet long and, as far as I am able to ascertain, is the longest steel power-pipe line in the world. It is riveted steel, made up in sections 20 feet long, fitted with pressed-steel flanges, and bolted together with round rubber gaskets between the flanges. The plates of which the pipe is made vary in thickness from 10 B. W. G. at the intake to 9/16 inch at the mill. The main line is made in three diameters. From the intake one-third of the way down, the pipe is 31 inches in diameter; the middle third is 28 inches in diameter, and the last third is 26 inches in diameter. The lower part of the pipe in the mill is 18 inches in diameter and made of 7/16-inch steel plate.

When the pipe line was completed the water was gradually turned in, about ten days being taken for this work, in order that the flanges

FIGS. 3 AND 4. TWO OF THE BRIDGES ON THE PIPE LINE.

might be tightened up where necessary. When finally filled the head gate was closed, and after a lapse of 24 hours it was found that there was no drop whatever in the pressure; this, considering the length of the line, is somewhat remarkable. The wheel connections are made of cast iron and lap-welded tubing.

Figure 2 shows the line at a point where the pipe enters a tunnel. As the country is exceedingly rough and rocky, it was necessary to make the pipe with a great many bends in it. A plan and profile of the pipe was made and sent to Spain for the contractors to do the grading, and to build piers, bridges, and tunnel. There are five bridges, and one tunnel through solid stone.

Figure 3 shows bridge No. 5, which has a grade of 34 per cent. Figure 4 shows bridge No. 3, which has a grade of 18 per cent. Figure 5 shows a pipe-locating gang.

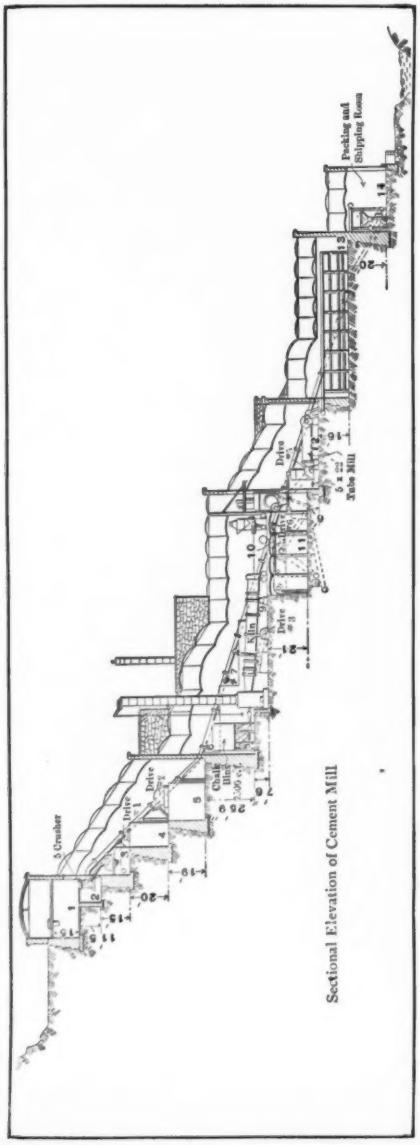
The nearest railroad station is Ripoll, some 35 kilometers from the mill, and all of the pipe line had to be hauled on carros by mules to the mill, and from the mill on specially constructed trucks to places near the line, and finally let down in place by means of capstans or winches. Figure 7 shows a part of the road which was built for hauling the machinery to the mill, and which will be used for transporting the cement. At present cement will be hauled to Hostelnou, which is about 7½ miles from the mill, by means of a locomobile and wagons. The railroad was built from Olvan to Hostelnou after the machinery was hauled to the mill.

FIG. 5. A PIPE LOCATING GANG.

The pipe enters the mill on level No. 1, which is the storage room for the stone as it comes from the quarries. The cement stone (or argillaceous stone) quarry is located at the back of the mill and a little above level No. 1. The stone is hauled in wheel-barrows and dumped

FIGS. 6 AND 7. THE MILL, AND A PART OF THE ROAD LEADING TO IT.

into this storage room. The limestone quarry is located some 500 yards away from the mill, and the quarried stone is hauled in tram-cars by gravity to the storage room, the cars being hauled back by mules. The coal mine is located some two or three miles away. At present the coal is brought down the mountain to the road by means of pack mules; here it is loaded into the locomobile wagons and hauled

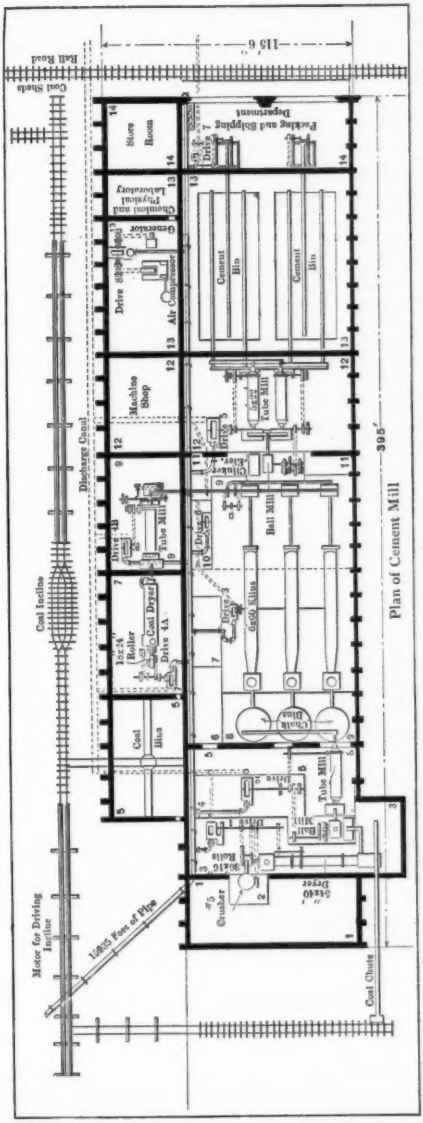


Sectional Elevation of Cement Mill

to the foot of the mill, and is elevated to the top of the mill by means of an inclined railroad.

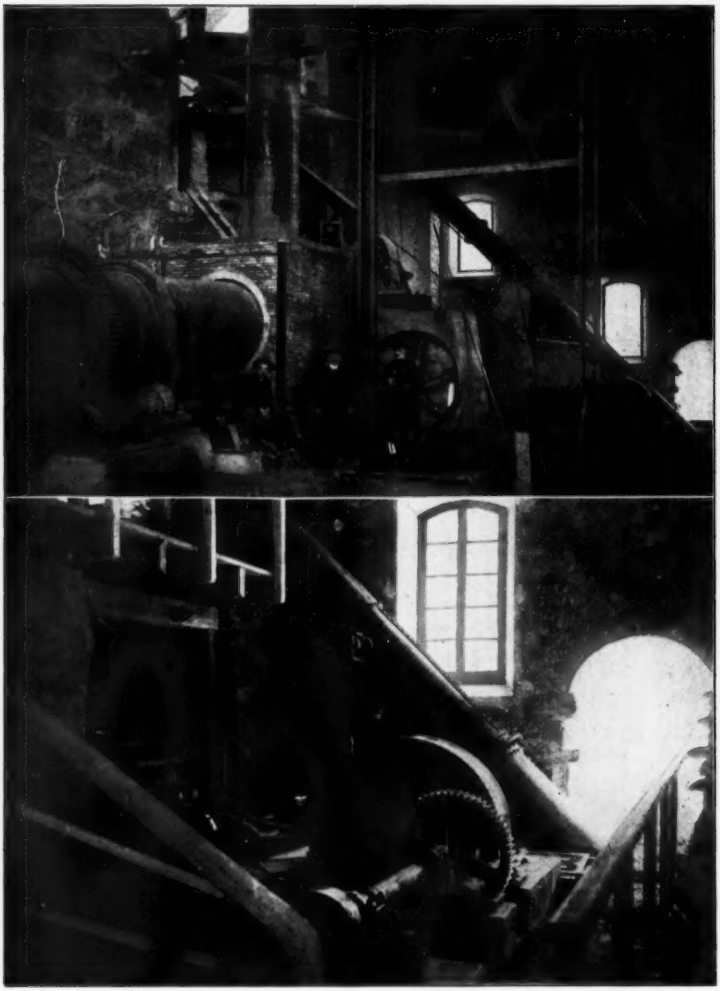
Figure 6 is a photograph of the mill, taken from the opposite side of the river. As will be seen from this, the photograph was taken before the stacks for the stone dryer and coal dryer were located. On this page is shown a sectional elevation of the mill, and on the opposite page a general plan of it. As will be seen from the plan, only one-half of the mill has been erected. The complete mill is to have six kilns and a capacity of one thousand barrels of cement per day. All the excavations for the second half have been completed, and the company expect to complete the whole mill in the near future.

On level No. 2 is located a gyratory rock crusher into which the weighed stone is thrown and from which the stone passes to a pair of crushing rolls. It then passes to the stone dryer on level No. 3. Figure 10 is a photograph showing the crusher, crushing rolls, and stone dryer. This constitutes what is called drive No. 1, the entire power installation being divided in-



to some ten "drives," corresponding to the various sections of the mill, each independently driven by a Pelton wheel of power adapted to the work required. No. 1 is driven by a 48-inch double-nozzle wheel, which has a maximum capacity of 220 horse power at 450 revolutions. Figure 11 is a photograph showing the wheel for drive No. 1. From the stone dryer the stone passes to a ball mill on level No. 4, and thence to a tube mill on level No. 5. The ball and tube mill constitute what is called drive No. 2, which is driven by an 88-inch double-nozzle wheel, having a maximum capacity of 350 horse power at 300 revolutions. From the tube mill the stone is conveyed by means of screw conveyors to the storage bins ready for the kilns. Figure 14 shows the kilns.

The coal mill is located at the side of the cement mill, being separated from it by a two-foot stone wall. The coal-storage room is located on level No. 5, where the coal is delivered to it from the inclined railroad. From this room the coal is conveyed to a pair of crushing rolls, from which it is delivered to the



FIGS. 10 AND 11. THE CRUSHER, CRUSHING ROLLS, AND STONE DRYER, AND THE 220-HORSE-POWER PELTON WHEEL DRIVING THIS MACHINERY.
The cement machinery was supplied by the Allis-Chalmers Co., general contractors for the installation.

rotary dryer. The rolls and dryer constitute drive No. 4-A, driven by a 48-inch single-nozzle wheel, which has a maximum capacity of 70 horse power at 560 revolutions. From the dryer the coal passes to the tube-mill hopper, from whence it is conveyed to the tube mill.

After the coal passes through the tube mill, it is elevated and conveyed across, by means of a screw conveyor, to the coal hoppers at the ends of the kilns. This constitutes drive No. 4-B, driven by a 60-inch double-nozzle wheel, which has a maximum capacity of 220 horse power at 450 revolutions.

In the present kiln room are three 60-foot by 6-foot kilns, driven by a 48-inch single-nozzle Pelton wheel, which has a maximum capacity of 70 horse power at 560 revolutions. The kilns are located on level No. 9. Just below the kilns, on level No. 11, are located the

FIG. 12. 350-HORSE-POWER PELTON WHEEL, DRIVE NO. 2—THE BALL AND TUBE MILL. 88-inch, double-nozzle; 350 horse power at at 300 revolutions.

coolers, one for each kiln. These coolers are supplied with air from a rotary blower. This blower, together with the blower for feeding the coal into the kilns, and the clinker elevator, constitutes drive No. 6, driven by a 66-inch single-nozzle wheel, which has a maximum capacity of 80 horse power at 400 revolutions. It may be noted here that the cool air enters the coolers at the bottom, passes up, and is drawn from the top of the coolers by the fan which blows the coal into the kilns. By this means, the coal is fed into the kilns mixed with hot air. The clinker falls from the coolers onto a belt conveyor and is conveyed to the clinker elevator. At this point the required amount of gypsum is added, for the purpose of regulating the time of setting of the cement. The clinker ball mill and finishing tube mills constitute drive No. 5, driven by a 91-inch double-nozzle wheel,

having a maximum capacity of 550 horse power at 300 revolutions. From the finishing tube mills, the cement is conveyed by means of screw conveyors to the stock-room bins, which have a capacity of 20,000 barrels. The stock room is located on level No. 13.

On level No. 14, twenty feet below No. 13, is located the packing machinery, driven by a 24-inch motor, with a maximum capacity of 35 horse power at 1,160 revolutions, being drive No. 7.

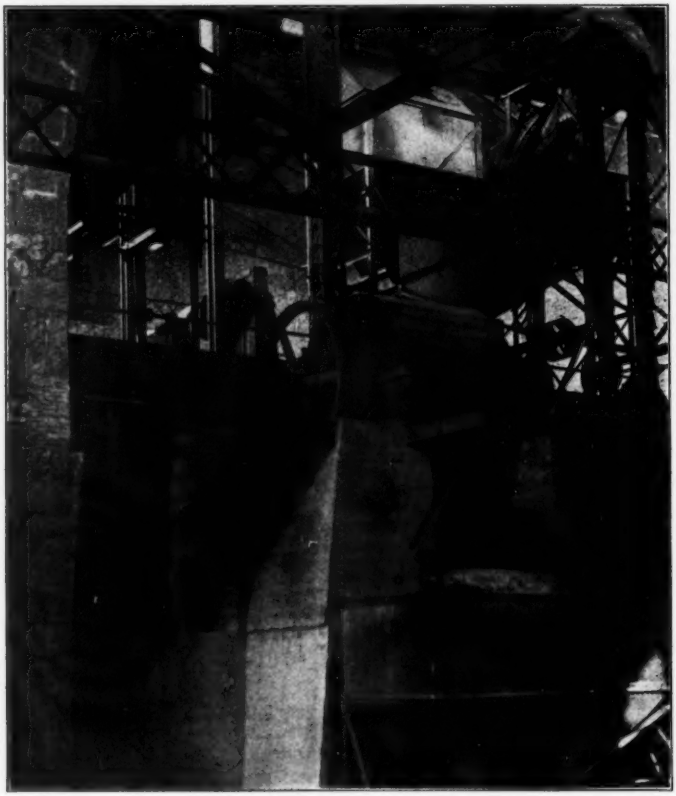


FIG. 13. THE FINISHING BALL MILL.

On level No. 12 in the coal mill is located the machine shop, fitted out with all necessary machines for making repairs. On level No. 13 of the coal mill is located an 85-kilowatt direct-current compound-wound generator, for lighting the mill and office buildings; also a 22¼ by 14¼ by 16-inch duplex air compressor, capable of driving eight 3-inch cylinder drills at 1,000 feet above sea level. The gen-

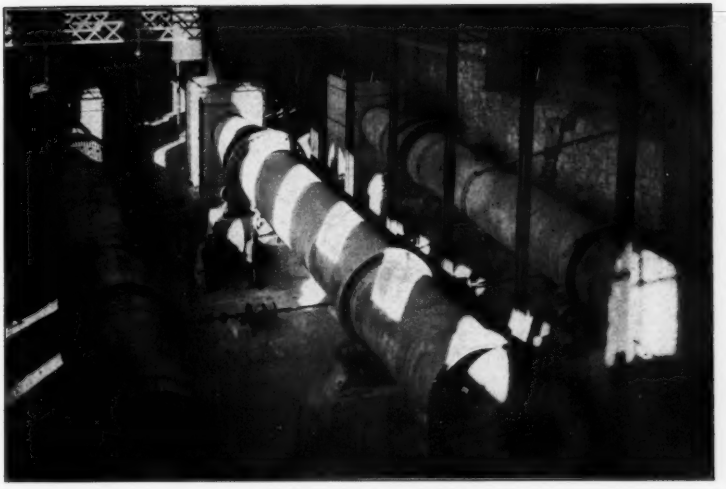


FIG. 14. THE KILN ROOM.

erator and compressor are driven by a 60-inch double-nozzle wheel, having a maximum capacity of 350 horse power at 450 revolutions. This constitutes drive No. 8. Figure 15 is a photograph of this drive. Adjoining the dynamo room is the chemical and physical laboratory.

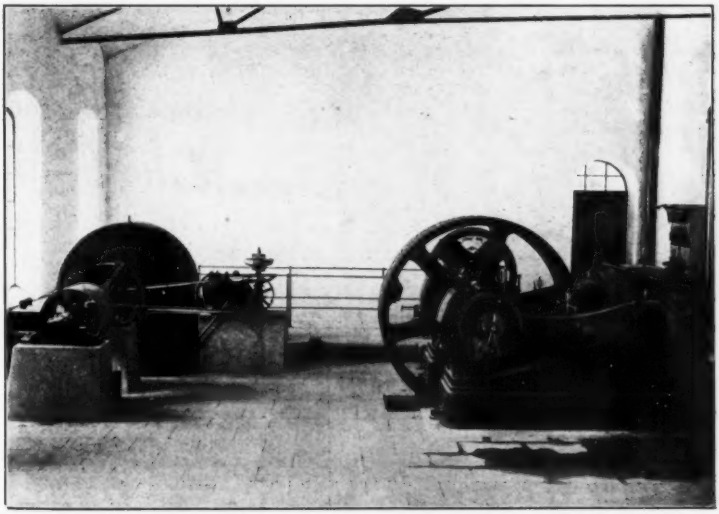


FIG. 15. THE DYNAMO ROOM AND 22¼ BY 14¼ BY 16-INCH INGERSOLL-SERGEANT AIR COMPRESSOR.

THE OFFICIAL TRAIN AT THE FAT SHAN OPENING OF THE CANTON-HANKOW RAILWAY.

THE ACTUAL BUILDING OF A CHINESE RAILWAY.

By Justin Burns.

In a preceding article, in our issue for November, Mr. Burns reviewed the general preliminaries to the construction of the Canton-Hankow railway line, in the middle south of China. He described—from the standpoint of the engineer in charge of construction—the official negotiations, the process of acquiring the right of way, the character of the country traversed, the organization and maintenance of the engineering corps, and the methods of conducting the field work under the peculiar conditions occasioned by the country and the people. In the following pages he takes up the actual work of building and operating the line, as exemplified by the first division opened.—THE EDITORS.

CONSTRUCTION was begun on the Sam Shui division of the Canton-Hankow line before starting the main line to the north. This division extends westward from Canton through the delta to the West, North, and Pearl rivers, and traverses rice fields for the entire distance with the exception of some abrupt irregular hills toward the western end. This delta country is flat and intersected with numerous navigable tidal diked streams, of which those crossed by the railroad rarely exceeded 100 feet in width. At Canton the dikes varied in height from 4 to 8 feet, but near the western end of the division dikes 30 feet in height were required to afford protection from the flood waters. The grade for the first

half of the division was so laid as to be slightly above extreme high water, but toward the Sam Shui end, wherever there were strong efficient dikes, these embankments were depended upon to protect the line from inundation. At the important streams the grade was raised to cross these rivers at a height sufficient to allow the passage of the hull of the larger cargo junks, since it was customary in Chinese bridge construction to inflict the inconvenience upon the boatmen of taking down their sails and masts in order to pass these structures. Against this hardship, the patient Chinese made no vigorous protests.

No trouble was experienced in finding Chinese eager to enter into contracts for constructing the earthwork or bridge masonry. In Hongkong there were many Chinese firms fully competent to manage and execute important and extensive construction work in the line of buildings. The erection of these large commercial structures had been superintended for years by European engineers, with the result that many Chinese artisans had been so educated in the work as to become proficient in successfully undertaking construction of a similar character. Consequently, with the railroad work, the suc-

AN EARTHWORK CONTRACTOR WITH HIS MANDARIN BACKERS.

The mandarin in the light-colored garments is a multimillionaire, his fortune having been amassed in the spice trade in Singapore. He had served as a director in the Chinese railways and proved himself an able and far-seeing business man.

cessful bidders were Chinese builders, mainly from Hongkong; but through ignorance of railroad requirements and this different class of construction, these contractors unfortunately bonded themselves to perform work at too low a figure to make money. If the earthwork could have been commenced when contemplated, at the openings of the bids, in the early winter, the low rate of six cents silver (two and a half cents gold) per cubic yard would have been sufficient for the contractors to make a profit, because the earth could be handled in the cool, rainless months of winter when the coolies were free from farm work, and when an inexhaustible supply of labor could have been obtained at a low figure. Unfortunately, the wheels of the local government moved so slowly that it was nearly spring before the proclamation was issued to permit the breaking of ground, and the unlucky contractors commenced their work at the beginning of the rainy season.

These Chinese practically completed their embankment contracts, but it was necessary to take the bridge work out of their hands and complete these structures under foreign foremen supervising native labor. In the case of the embankments, it was not difficult to obtain coolies who had been skilled in the handling of clay in constructing and repairing the innumerable dikes which filled the country. With these Orientals the element of time never seemed to be thoroughly understood, and, generally speaking, no contractor ever paid any regard to the completion of his work at the time promised. Their training and education could find no reason for the impatient urging of the foreign engineer, who used all means known to both civilizations to impress upon the Oriental mind the importance of the obligation of finishing within a limited period.

Much has been written in praise of the Chinese characteristic of faithfully fulfilling a contract or business obligation in the spirit and letter of the agreement, even though there were no written evidence of a promise, and even though the transaction would involve pecuniary loss to the Oriental. It is to be regretted that this railway work in South China cannot substantiate this much quoted and praised characteristic. It may have been that the Chinese builders were reared in a different school of business ethics from the merchants; the railroad contractors were certainly thoroughly grounded in the fine arts of equivocation and scientific dishonesty of action and intent.

"Squeezing," or the retaining of a certain percentage of money which passes through his hands in the payment for labor or materials, is rated by the Chinese as one of the perquisites of his position; the

severe measures visited upon the detected offenders rarely convinced the Oriental mind that the foreigner wanted absolute honesty. But the practice of this extortion of money penetrates all classes of Chinese, from the lowest head coolie to the highest throne official, and it forms one of the ineradicable evils which has to be diplomatically handled to construct successfully in Chinese territory. If the poor coolie can be justly treated, and taught to realize that the railroad enterprise will bring full value for his labors, it will be difficult for the opponents to the introduction of foreign ideas to present effective arguments counteracting this material prosperity, which would arise from the additional employment and money given to the thousands of families by reason of this new work. The ill-treatment of the laboring classes in the construction of the railroads in the northern parts of the Empire has often been asserted to be the indirect cause of the uprising of the natives against foreigners in 1900.

CONTRACTORS' COOLIE SHACKS CONSTRUCTED OF PALM LEAVES AND BAMBOO POLES. A kitchen is seen in the foreground with the temporary clay fire places and the kettles for rice.

In order to hasten the construction of the Sam Shui division, some of the work done in the high embankments and deep cuttings was performed by day labor under the supervision of foreign foremen; but this work proved costly. The results deduced from the various methods of conducting work indicate that the greatest economy in the cost of construction can be obtained by letting small sections of the work to innumerable petty contractors, without the intermediation of

EXCAVATIONS IN SOFT EARTH. THE UPPER VIEW ILLUSTRATES THE USE OF SLEDS IN TRANSFERRING CLAY BLOCKS TO THE EMBANKMENT. THE LOWER ONE SHOWS WOMEN IN THE BORROW PITS, SLIDING BLOCKS OF CLAY ALONG BOARDS.

general or supervising native managers. This removes an opportunity for squeezing, and affords a greater probability that the coolie will receive his full pay. The small contractor is often co-operative with

his laborers; when the native is working so that his greater individual effort brings him greater gain, his efficiency is increased to many fold that developed under hire at a daily stipend.

The first contracts of five-mile sections were sublet by the Chinese contractors to various lesser contractors, who were generally the heads of families or communities; these sub-contracts for three or four hundred feet of embankment were taken at a certain unit rate which was sufficiently low for the general contractor to realize some profit from the work. The sub-contractor utilized all members of his community or family to fulfil his contract, and often not only men, but women and children, filled the borrow pits. It was a common sight to see gangs of laborers composed entirely of women, many of whom worked with their infants strapped to their backs. It might be interesting to state that the women coolies formed more efficient and less troublesome earth laborers than the men. The inciters of strikes and labor riots seemed to have less effect upon these unfortunates.

BLOCKING OUT THE CLAY WITH THE TWO-HANDED SPADE AND TOSSING THE BLOCKS TO THE EMBANKMENT.

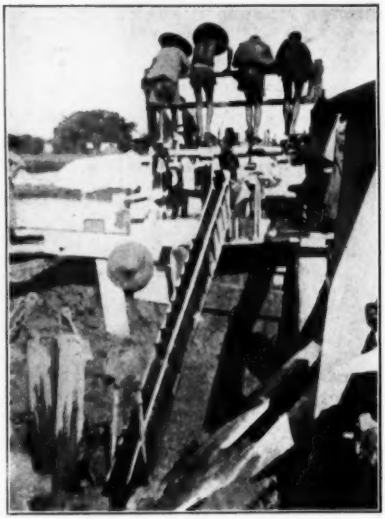
The rice fields are of dark blue clay, which overlies the rock to a depth varying in this delta country from 20 to 50 feet. Where the ground was moist and the clay tenacious, the material in the borrow pits was cut by spades into blocks each containing about a quarter of a cubic foot. These blocks were transferred to the embankments in various manners which depended upon the ingenuity or desire of the

"SANDPAPERING" THE CUTS.

sub-contractors. On the low embankments it was usual to place coolies in rows extending from the borrow pits to the embankments, and to toss the blocks of clay from hand to hand until placed in the construction. Another method which proved economical was to lay planks from the borrow pits, and by posting workmen along these boards at short intervals the blocks of clay were slid on the wetted planks until finally placed in position in the fill. Then, again, sleds, drawn by the coolies over roadways of wetted clay, were used to transfer large loads of blocks to the embankment.

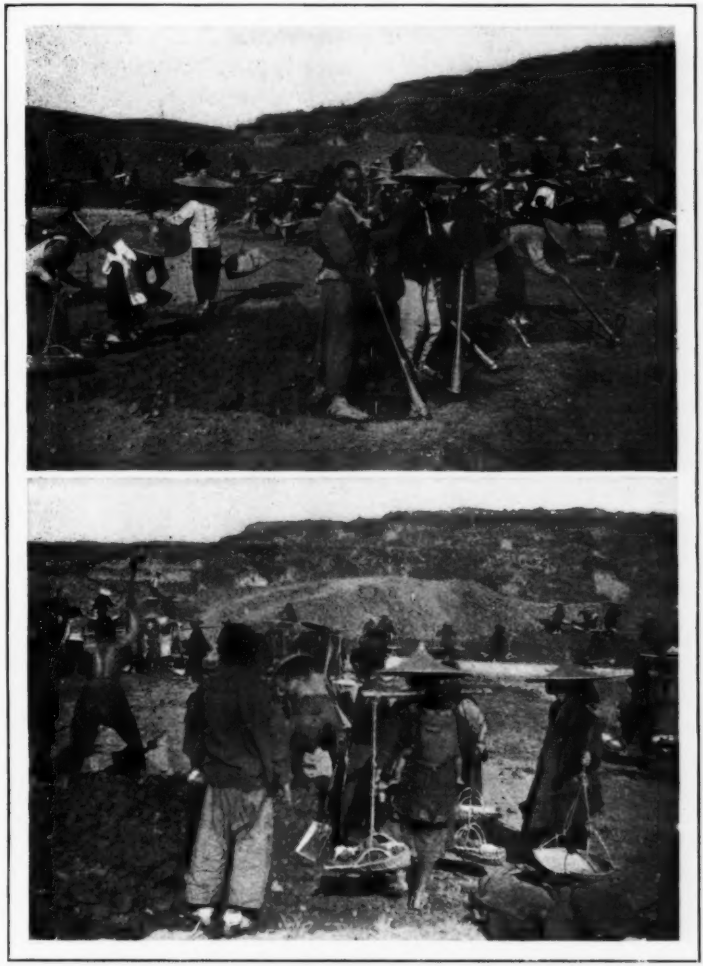
Where the clay contained a certain percentage of sand, the blocks did not retain their form sufficiently to permit tossing or sliding, and in these cases baskets suspended at the ends of bamboo shoulder poles were in general use.

In all the high embankments and hill cuttings the transportation of material in baskets was the only method employed. The attempt was made to use wheel-barrows, but this was economically a failure either through the inability or the unwillingness of the Chinese to utilize this innovation. Although wheel-barrows are used to great extent in other portions



CHINESE WOODEN CHAIN PUMPS, OPERATED BY A TREADMILL.

These pumps were used for removing the water from the coffer-dams, and for a low lift they are very efficient.

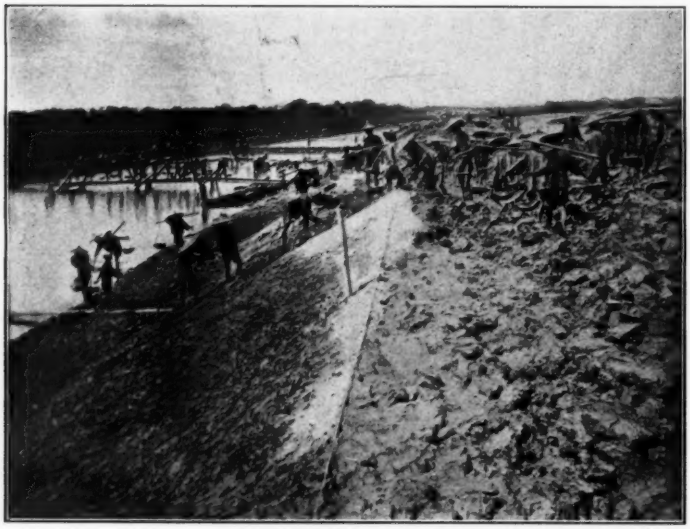


EXCAVATIONS IN HARD EARTH, SHOWING WOMEN COOLIES CARRYING BASKETS OF CLAY; THE ONE IN THE FOREGROUND OF THE LOWER PICTURE HAS HER INFANT STRAPPED TO HER BACK.

of China, they are little known in South China, and therefore the coolies seem to make best progress with the methods in handling dirt which had been familiar to their predecessors. There are no horses or carts in this roadless country, and so their economical employment

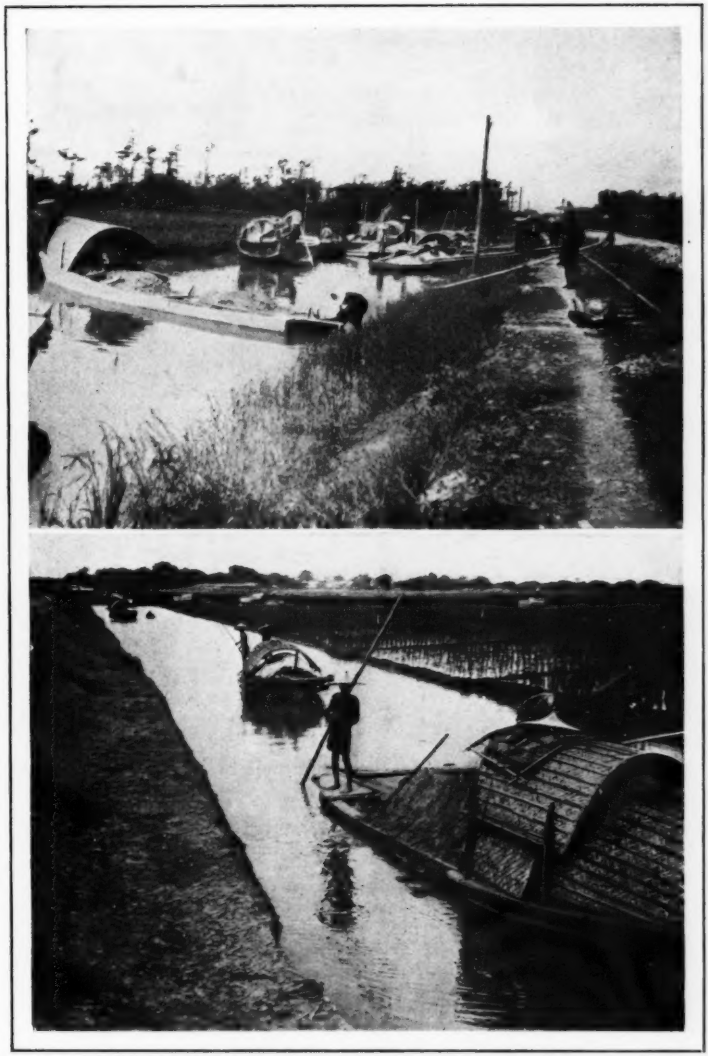
could not be made use of in the dry hill cuttings. Occasionally a little plowing was done by the water buffalo or carabao, and with this rare exception all of the earth work was done by hand labor.

In the rice fields and low ground the tools used were both long handled and short two-handed wooden metal-tipped spades which blocked out the clay. In the dry earth and in the hill cuttings the coolies used a heavy metal-tipped wooden hoe to cut out the earth and drag it into the baskets. When the clay was hard and compact, foreign picks and shovels were used. The excavation in hard earth was a new feature to the coolies who had few native tools suitable for this work.



FINISHING SOME OF THE HIGHER EMBANKMENTS.

During the construction of the embankments, care was taken that the borrow pits from which the earth was removed should be excavated in a definite regular manner. At the completion of the embankments these borrow pits were generally connected with the streams and formed two waterways parelleling the railroad. The farmers quickly realized the advantage of these canals in affording convenient assistance in cultivating, irrigating, and harvesting their rice crops. Where for fear of inundations it was not advisable to cut through the dikes to connect with the larger streams, the borrow pits



BORROW PITS REGULARLY EXCAVATED, AND USED, AFTER THE CONSTRUCTION OF THE LINE, AS CANALS FOR THE TRANSPORTATION OF BALLAST AND OTHER MATERIAL.

DRIVING PILES FOR BRIDGE FOUNDATIONS.

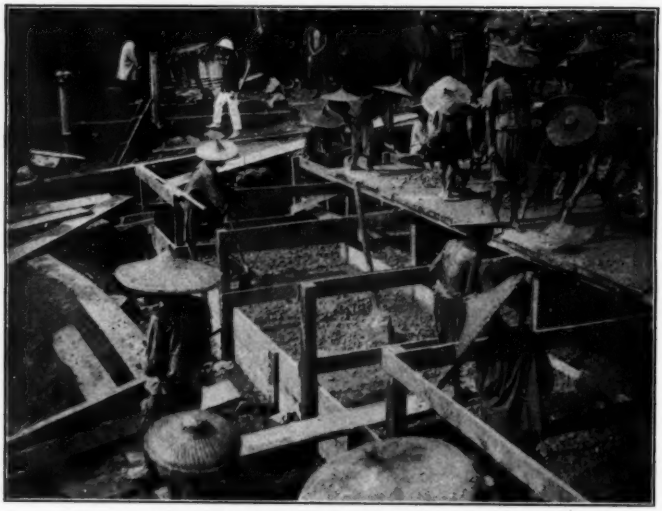
Below is shown the interior of a coffer-dam, with coolies engaged in cutting off piles for masonry. One of the wooden chain pumps, shown on a large scale on page 386, may be seen in the background.

adjacent to villages often were stocked with fish and afforded a supply of this food for the villagers.

The contractors in bridge masonry failed in the fulfillment of their agreements, because of the fundamental deficiency in the Chinese mind which could not conceive what it had never actually seen. Yet after the native had observed how the coffer-dams were constructed and filled, how the pile foundations were driven, how the concrete forms were erected and placed, how the cement, sand, and stone were mixed and deposited to form solid masonry, they were ready to proceed with other construction which involved these methods.

A BRIDGE SITE AT THE COMMENCEMENT OF THE COFFER-DAM WORK.
In the background is a Chinese village, with an ancient five-span stone-arch bridge.

Throughout this delta country the concrete abutments and piers of the bridges were founded upon piles, the timber for which came from the mountains hundreds of miles up the West River. Unless the expensive hard woods from the Straits Settlements or the Philippines or timber from America were imported, no other wood was obtainable excepting this China fir, which is similar but quite inferior to American spruce. The logs probably deteriorated considerably in their rafting from the forests to market, since this journey often consumed years. No difficulties were experienced with this work, although in one bridge adjacent to a sink-hole it was necessary to use spliced piles to a depth of 90 feet in the bridge foundations. The



CHINESE LABORERS DEPOSITING CONCRETE IN BRIDGE MASONRY.

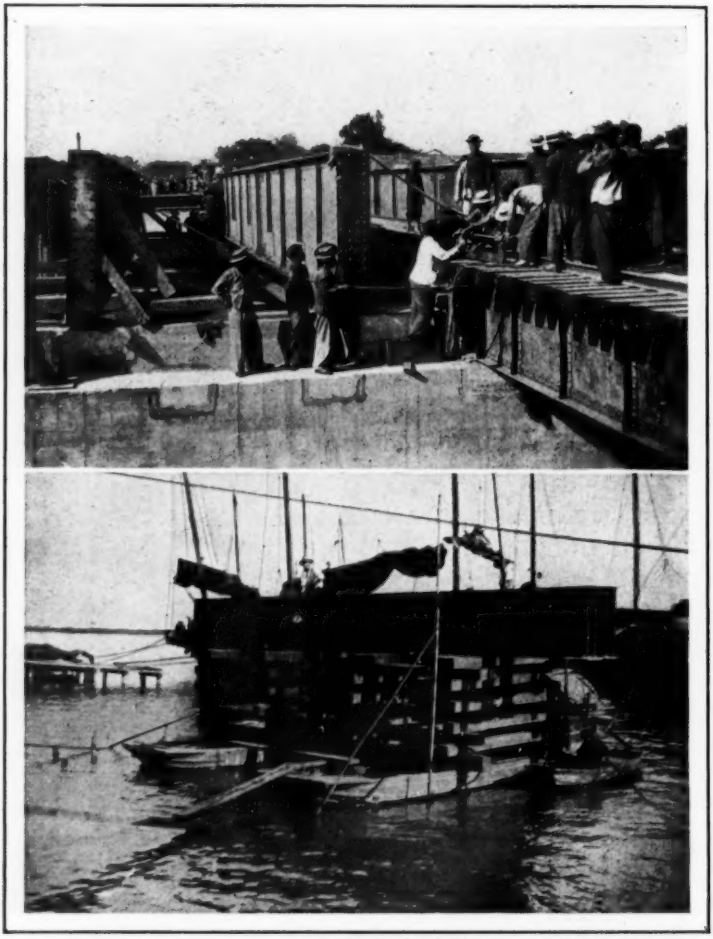
broken stone for the concrete was transported from the quarries a hundred miles up the North River; the sand was dredged from the river bottoms; the cement was an excellent product from Hong Kong and Macao, being locally manufactured there from the clay deposits near Green Island, adjacent to Macao, and the Ying Te limestone quarries of upper Kwang Tung.

The superstructure of the bridges was of steel girders, none of which exceeded 65 feet in length. It needed little computation to show the necessity of the reversal of western practice in economical span lengths. The cost of steel delivered at the bridge sites in China was so high, and the cost of masonry constructed by unskilled labor was so low, that economy pointed to short girder spans and numerous piers. The contraction of the channels of these tidal streams caused little or no erosion, and so long as an opening was left sufficient in width for the passage of the junks engaged in the commerce of that stream, no objection was made by the natives to the narrowing of the waterways.

The convenience with which the short spans could be transported in the small native junks to the bridge sites, and the ease with which they could be erected, were factors strongly advocating their use. In the construction of the main line to Hankow, no difficult problems of bridge construction will be encountered such as occur in the

CHINESE MASONS SETTING BRIDGE SEATS, AND CHINESE STONECUTTERS AT WORK.

Belgian line at the Yellow River, although some bridges of two or three hundred feet of span will have to be erected in the mountains. The types found economical on the Sam Shui division will be the standards in the main-line work.



ABOVE, CHINESE BRIDGEMEN ERECTING THE THROUGH-GIRDER SPANS; BELOW, GIRDERS CRIBBED UP TO BE SET ON THE MASONRY BY AID OF THE TIDE.

In the bridge erection, native labor was employed under the direction of foreign foremen. These coolies were from the shipyards and boiler shops in Hongkong and they soon became efficient bridge riveters. The erection of the steel structures presented no obstacles which were not easily overcome by this Chinese labor. The smaller spans were transported by junks to the bridge sites and, where pos-

sible, were placed on the masonry by aid of the tides. The larger girders were transported by rail and erected from temporary trestles as the track laying progressed.

CHINESE BRIDGEMEN RIVETING LONG GIRDERS.

In the double-tracked portion of the division, from Canton to Fat Shan, the rails were laid on steel ties of a rolled section with bent ends; for the single-tracked remainder of the line to Sam Shui, Japanese oak ties were used. The tracks were stone ballasted as fast as the leisurely working native contractor would supply the material; but river sand formed a temporary substitute so as not to delay the operating of the railroad.

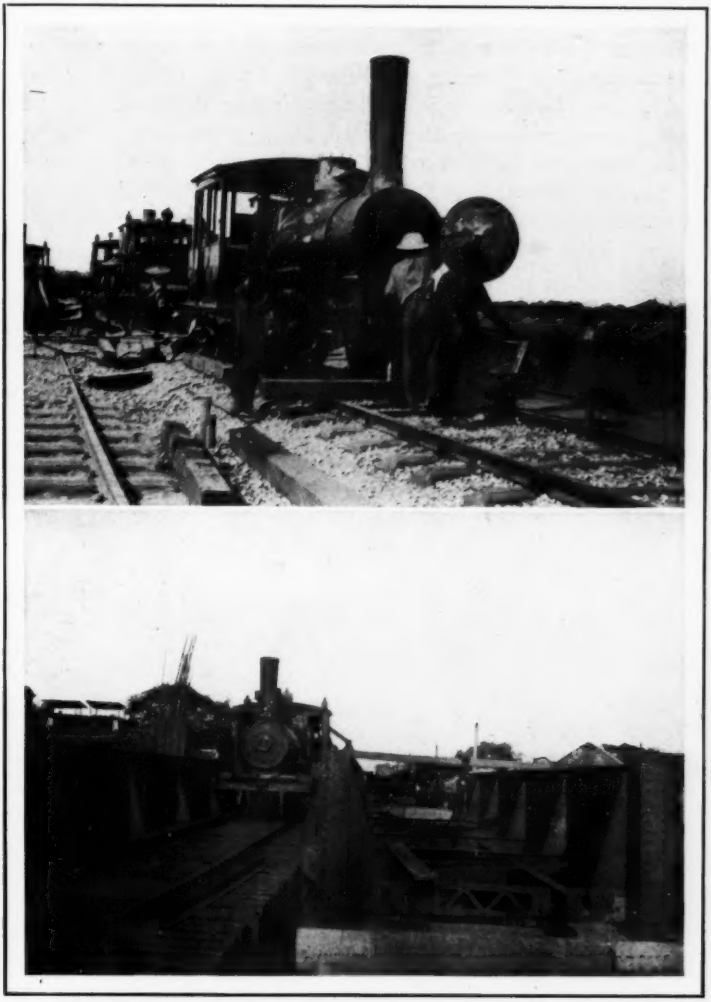
The economical type of track construction can only be evolved from experiments with the various kinds of rail support in this tropical climate of Kwang Tung. The enemy to everything wooden is the white ant, while to everything iron it is the humid atmosphere. Experiments were begun with ties of various kinds of wood, both from America and Asia, but the results of these tests can scarcely be apparent until after the lapse of several years.

The line to Fat Shan and later to Sam Shui was opened for operation with the ostentation, pomp, and noise which so delight the Oriental senses; the bedecked trains were greeted everywhere with volleys of firecrackers expressing the Chinese wishes for prosperity.

A CHINESE TRACKLAYING GANG MAKING UP A CONNECTION.

At the Fat Shan opening in November, 1903, the rolling stock was incomplete, so that flat cars with temporized sides and roofing composed the official trains. It happened that the opening occurred upon a Chinese feast day, so that it was necessary to devote two days to the opening celebration, the first being for the foreign residents

COOLIES STONE-BALLASTING THE LINE.

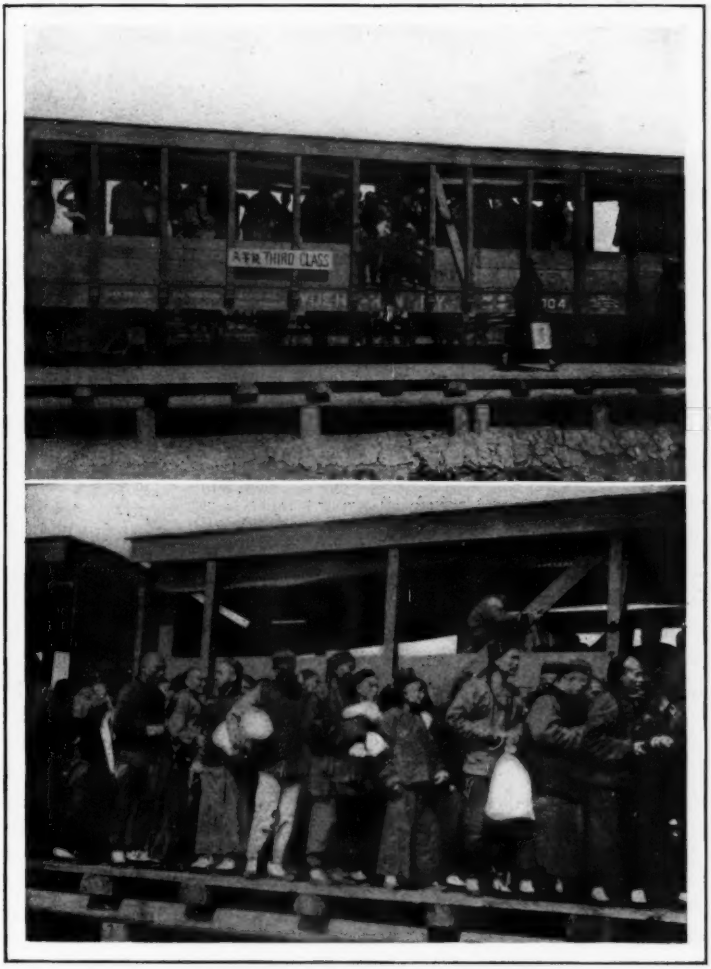


SOME OF THE FIRST MOTIVE POWER OF THE LINE.
The upper view shows the assembling of an old locomotive from the Manhattan Elevated R. R. of New York. The lower shows one of these engines in service, and the type of through girder bridge adopted.

and representatives of foreign governments and the second for the Chinese officials and mandarins. The event naturally proved of great interest to the whole country since it was the first display of a conveyance of such a character ever beheld in South China. If the railroad had been better equipped at the opening for the handling of passengers in accordance with western ideas, much greater pleasure would have been experienced by the engineers in displaying their work to the Orientals and the representatives of the foreign governments. Yet the Chinese had never seen better and to their conception of convenience and luxury, these cars proved attractive and comfortable.

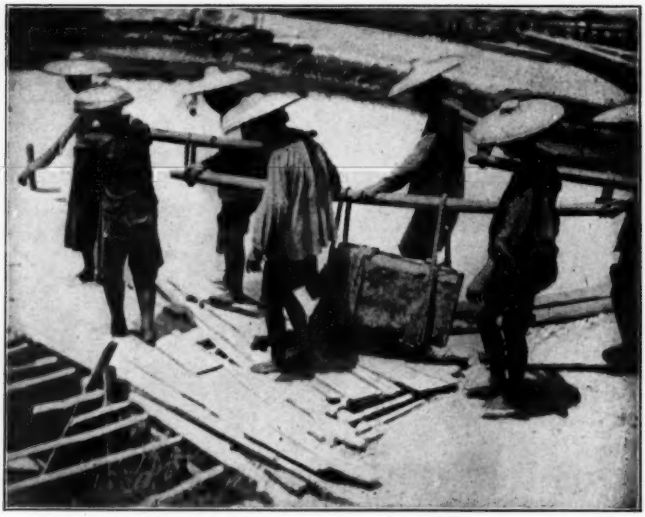
THE CHINESE OFFICIALS AND POPULACE AWAITING THE OPENING TRAIN AT FAT SHAN.

The division was operated for some months with these improvised coaches before the passenger cars arrived; the short runs were admirably adopted to the former Manhattan Elevated Railroad locomotives which were used in this division for passenger trains. This traffic was divided into three classes, as is customary outside of America. Some degree of comfort was provided for the first and second classes, but the third was carried in flat cars without seats or other conveniences. The apprehension that the Chinese people would prove too poor to support a railroad was quickly dispelled by the rapid growth of passenger traffic, which soon taxed the limited facilities for handling the patronage. The passenger rates per mile were, first



THIRD-CLASS PASSENGERS AND CARS.

The flat cars were fitted with temporary sides and roofs. The lower view shows a train load of passengers, just unloaded.



CHINESE METHOD OF MULTIPLE LEVERS IN CARRYING HEAVY LOADS.

Suggesting a native attempt at mechanical aid to manual labor.

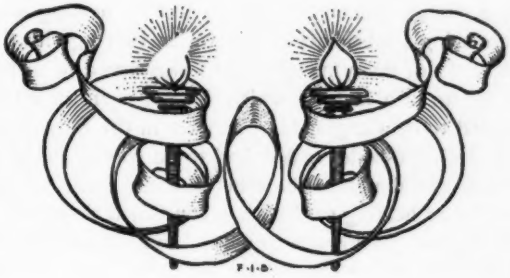
class, 5 cents (silver); second class, 2½ cents; and third class, 1½ cents. It is needless to say that the greater part of this traffic was in the third class, and the Chinese found it suited their pleasure to crowd in and squat on the floors of these flat cars in solid contentment.

The Sam Shui division will be used almost entirely for passenger traffic and in that capacity it greatly appeals to the Chinese on account of the quickness and the safety with which passengers can travel from Sam Shui to Canton. Previous to the opening of these 30 miles of railroad, this trip was from 40 to 90 miles by water and consumed from six to eighteen hours, dependent upon the means of transportation and the depth of the water in the various channels. These streams in the delta are infested with river thieves so that the voyage of a merchant with valuables is attended with much pecuniary risk and personal danger.

The construction of the main line north from Canton was commenced in January, 1904, but on account of the disturbed condition of affairs in the Orient, this work has proceeded slowly. Although the railroad thus far built and operated is a meager beginning toward the completion of the whole project, yet it is a successful effort and

will serve as an entering wedge to open the Chinese minds to the realization of their errors of conservatism and superstition.

Regarding the efficiency of Chinese labor, the results of this railway construction would tend to give favorable reports. In excavation where the coolies are familiar with the work, the earth was handled at an extremely low figure; but when the embankment was high or the hill cutting deep, the methods known to the coolies were more expensive than if modern means and appliances had been used. It is a mistake to suppose the Chinese incapable of handling labor-saving machinery, and it is a mistake to believe that the employing of an inexhaustible supply of cheap hand labor is more economical than the training of the natives to operate machinery. The Chinese readily become skilful mechanics, and it needs merely capable superintendence to instruct and direct them in their work. As an illustration of the mechanical ability of the Chinese, all of the smaller steam craft and many of the ocean-going steamships in Chinese waters are operated entirely by Chinese engineers and firemen. In handling locomotives the natives quickly learn their duties; in bridge construction they prove efficient iron workers; in machine shops they become experts; in stone cutting, in masonry, in carpentry, in metal working, they are proficient in their crafts.



EXPERIMENT AND PRACTICE IN THE CONSTRUCTION OF STEAM BOILERS.

By Egbert P. Watson.

NEARLY forty years ago the leading engineers of that period met at the Centennial Exposition and agreed upon a rating for the horse power (so called) of steam boilers. This was the evaporation of 30 pounds of water per hour from feed water of 100 degrees to steam of 70-pounds gauge pressure, and it was based upon the average consumption of steam by well designed engines of the day; but since that time a great advance has been made in several directions, both in the boilers and the engines, so that the formula is no longer an expression of the capabilities of either. Notwithstanding the fact that there can be no such expression of the efficiency of a steam boiler, boilers are still rated by horse powers in buying and selling them. The only thing which fixes the power of a boiler is its ability to turn water into steam, and its true rating is the number of pounds it can deliver in a given time.

Horse power, as applied to a steam boiler, is a particularly unsatisfactory designation to all concerned, both buyer and seller, for the reason that there is no base to determine what a horse power is. An order for a 25-horse-power boiler would be filled by the builder with one having a certain number of square feet of heating surface, the grate surface being a subsidiary consideration, varying with the notions of the builder. Not many months ago I was asked to inspect a new boiler, just set up in a factory, which did not perform satisfactorily. It was intended to be a duplicate of another in the factory which had done well, and all the boiler maker had to do was to follow the copy. One boiler was set alongside the other and the stack was ample for both. In so far as heating surface was concerned there was no lapse, but for some reason unknown to any one (and not given by the boiler maker) he had cut off 18 square feet from the grate surface, which was the cause of its difficulty in making steam. The grate surface is a very important detail, but there seems to be no hard and fast rule for the ratios of grate to heating surface observed by the trade. The same is true of the smoke stack, and the whole procedure as to the proportions of steam boilers varies all over the country, except in the

case of some insurance companies who prepare the designs of the boilers they will insure.

Fixing boiler power by the square feet of heating surface is a legacy from the days of Watt. The engines of that period were very defective mechanically, and required 62½ pounds of water for one horse power; the evaporation was very low, also—only 4 pounds of water per pound of coal; consequently, 15 square feet of heating surface were needed for one horse power. Even to this day this ratio is observed by some boiler makers, and this amount of heating surface is given in comparatively modern text books as essential to good performance. It follows that with modern furnaces, and a better knowledge of both the theory and practice of burning fuel to the best advantage, boilers are too large and, consequently, cost too much for a given duty. "Too much is just about enough" is, apparently, the rule for heating surface and other details.

Considering the wasteful and even reckless disregard of the cost of fuel by steam users generally, it is not surprising that the conditions named above obtain, for in the eyes of the average buyer a boiler is like a conjurer's bottle, in that it will furnish steam indefinitely, with any sort of mismanagement and any kind of fuel. Its functions should continue so long as there is a valve on it to open; when there is not, one or more can easily be attached. A short time ago a person bought a boiler of me for a certain specified duty; after it had been tried he declared that it was not up to its rating and demanded his money back. Investigation revealed that, in addition to the work it was sold for, there were two dye-vats with coils therein for which the boiler was expected to furnish steam. No sort of reasoning could convince the buyer that this was a great tax on the boiler, and he refused to be comforted. I thought to circumvent this weakness of steam users by stating specifically in a circular that boilers were sold on a guarantee to do the work named in orders and no other; but it availed nothing, for customers continued to hitch on steam pumps, heaters, etc., which demanded live steam, and complained as before that the boilers were not large enough. Purchasers of boilers should be careful to state every attachment to a boiler requiring live steam, and every use to which it is to be put, for in the event of a short supply they have only themselves to blame.

As stated in previous lines, boilers are still made by rule of thumb—or, to speak exactly, by methods which have given satisfaction to customers generally. Tables have been prepared, and published in all hand-books upon boiler making, which fix the power of certain types

when so many tubes of a given diameter and length are supplied; but the builder must decide for himself upon the ratio of grate to heating surface and the diameter and height of the stack. As these last have great influence upon the efficiency and economy of a boiler, it does not seem as if the boiler maker gained much by having the heating surface alone furnished him. It goes without saying that every boiler which has a specific duty to perform should be designed for it, but so long as steam users continue to guess at the power they require, boiler makers will continue to guess at the size they need.

It has been asserted in previous lines that the rate of evaporation a half-century ago was very low—from 4 to 5 pounds of water per pound of coal only—and corroboration of this fact is found in an experiment made in 1858 by B. F. Isherwood (formerly engineer in chief, United States Navy,) upon a boiler in the Brooklyn Navy Yard, which was, as boilers were then built, typical of its kind and class.

The boiler was of the drop-flue type, 48-inches diameter by 24 feet long, having five flues 12-inches diameter by an average of 15½ feet long. The heat entered the upper row of flues first, then descended to the row below, and finally dived into a large horizontal flue from which the gases went to the chimney. The boiler was set in masonry and had a total heating surface of 379½ square feet; the grate surface was 19½ square feet, and ratio of one to the other nearly 20 to 1. The evaporation per pound of good coal was from 3.60 to 4 pounds only, with feed water at 100 degrees. This is a very poor performance, apparently, but the consumption of coal was only 9.67 pounds per square foot of grate, using forced draught at that. A modern Lancashire boiler, which is very much of the same type, will easily burn 24 pounds of coal per square foot of grate with natural draught, and evaporate 8 pounds of water per pound of coal.

Another boiler experimented with by Isherwood was the Ellis, very similar to, and indeed almost identical with, the modern return-tubular boiler in universal use to-day, both in proportions and results. It evaporated 9.07 pounds of water per pound of coal from 100 degrees feed water to 35-pounds gauge pressure; from and at 212 degrees the evaporation was 11.57 per pound of combustible, which, says the author, "was a very mediocre result." If it was it has not been improved upon in nearly half a century.

In view of the moot point—the relative merits of fire-tube and water-tube boilers, still discussed—it is interesting to note Isherwood's conclusion from experiments carried on with two boilers of the kinds mentioned, of very nearly the same dimensions, in the same vessel—

the San Jacinto, U. S. N. It was intended to be a "rigorously comparative experiment," there being no differences except in the types of the boilers. The observers, or experimenters, were B. F. Isherwood, William E. Everett, John Faron, and James A. King, all chief engineers of the Navy.

Without burthening this article with repetitions of figures it is only necessary to say that the boilers were identical, with one exception:—the water-tube boiler had 27½ per cent. more heating surface than the horizontal fire-tube boiler, the grates being the same in both boilers. The very low rate of combustion, however, and the pressures carried—10½ pounds for the fire-tube boiler and 11½ for the water-tube boiler, burning only 9.68 and 8.92 pounds of coal, respectively—deprive this experiment of the interest which would have obtained had the conditions been more like those with the vessel *en route,* doing her best. Summarizing the results in the words of the demonstrators:—

> "If the maximum absolute weight of the steam that can be procured in equal times be alone considered, the horizontal fire-tube boiler for equal dimensions has an advantage of 10½ per cent. over the water-tube boiler."

This verdict is qualified further on, in a more exhaustive analysis of the performance (page 168, Engineering Precedents, Vol. 2) by these words:—

> "The weight of steam furnished in equal times by both boilers being equal, and equal space being occupied in the vessel for both boiler and coal, the vertical water-tube boiler at its maximum rate of combustion has the great superiority of furnishing 27½ per cent. more total weight of steam than the horizontal fire-tube boiler at its maximum rate of combustion, while at the same time the aggregate weight of boiler and coal will be the least."

It is interesting to note in these boilers of 1858, forty-six years ago, that the horizontal fire-tube boiler was, to all intents and purposes, the counterpart of the Scotch boiler, so called, in use today, except that it had water legs, while the water-tube boiler bears no resemblance to the modern boiler of its class. Externally it was the same as the boiler of the period, having a shell all over ⅜-inch thick, internal firebox, water legs, and water bottom, and a cumbrous uptake where the gases emerged into the smoke stack. Moreover, the tubes were vertical, but the products of combustion passed through them transversely, so that the action of the heat was the same as if the tubes had been horizontal. This was a Martin boiler designed by a chief engineer of the United States Navy. There was a solid bank of brass tubes of 2-inches outside diameter, 3 feet by 7 feet, through

which the gases and products of combustion passed; the tubes were spaced 3½ inches from center to center, with ample space above and below to clean them, and with distilled water from a surface condenser the boiler would doubtless have given a good account of itself; but its rate of evaporation on the San Jacinto, which had a Pirsson condenser, was not high—only fair—being but 7.8 pounds of water at a feed temperature of 100 degrees, per pound of coal.

Small tubes in boilers were looked at askance in those days, and it was predicted that these would soon become clogged by scaling, unless fresh water was used. This was practically impossible at that time, for surface condensers had not come into general use, jet condensers being the rule on all sea-going vessels. As a consequence tubulous boilers soon lost their efficiency, and the Martin boiler was no exception. I have seen boilers of this type after a trip from Havre to New York (on the steamers Arago and Fulton) come limping in with 5 or 6 pounds of steam, it being impossible to get any more owing to the tubes being chock-a-block with salt, or a saline stone which was like flint for hardness.

So many of the tubes were affected in the way described that the heating surface was cut down materially; those not absolutely solid with scale were so covered internally that the waterway was not over ½ inch in diameter. This might have been caused in part by mismanagement, but it occurred trip after trip, after the engineers had become familiar with the boilers' peculiarities, it being practically impossible to prevent it where salt water in any quantity was fed.

Respecting the design of this boiler, it is apparent that it was not a water-tube boiler pure and simple, but a compromise between a fire-tube and a water-tube boiler. It had legs and a water bottom which needed stay bolts, and an exterior shell which had to be braced; as a consequence, it was but a few pounds lighter than, and took up just as much space as, an ordinary steam boiler. In view of these features it gained nothing by comparison with the usual boilers, except a slight increase in evaporation and economy, with a longer radius of action. Contrasting it with modern water-tubular boilers it appears at a great disadvantage; our forebears had not then learned the trick of dispensing with the shell of a boiler and likewise the steam dome, substituting for the latter appurtenance a drum which occupies but little space and fulfils all the conditions. It is noteworthy, too, that while the modern water-tube boiler has achieved extreme lightness, the fire-tube boiler has gone the other way and is enormously heavy. The improvements made in it consist of removing the legs

and water-bottoms and making it cylindrical externally. To enable it to carry the higher pressures demanded by modern practice, the shells have been greatly increased in thickness, and braces and stay bolts as well; the weight of boiler plates used a half-century ago was about 12½ pounds per square foot, but now the shells of high-pressure marine boilers will weigh from 40 to 50 pounds per square foot. Evaporation, however, has been doubled, while the amount of coal which can be burned per square foot of grate has been raised from 9 or 10 pounds to double that quantity with natural draught only.

Of the boiler itself it is scarcely necessary to speak, for there is no comparison between the steam generator of today and that of fifty years ago, in material, design, or workmanship. Steam boilers in these days are as carefully made as engines, and should have a much longer life.

This dissertation would be incomplete without some reference to the thermodynamics of the subject, which to the enthusiastic student of boilers is one of the most interesting branches connected with it. It is, in itself, an abstract study, because so much must be assumed as a base for argument, but that which is known or accepted as fact claims attention. For example:—the possibilities in the burning of one pound of pure carbon in a laboratory are the evaporation of 15 pounds of water, and essayists dwell upon this point in comparing the efficiency of modern furnaces and the amount of water evaporated in practice. But between the chemical laboratory, so to call it, and the crude retort of the steam-boiler furnace there is a very wide margin for error and loss of efficiency. For one item, the fuel itself is by no means pure carbon, or anything approximating to it; analysis shows that the constituents of commercial coal vary greatly. Even in the mine itself this difference shows; but it is all "coal" to the steam user, and he must do the best he can with it. After he has the coal, it is thought sufficient to shovel it into a furnace of some sort—let in too much or too little air, and take the chances of evaporating more or less water for every pound of it. Firing a steam boiler for high efficiency is by no means a handicraft, but a study of all the conditions prevailing for every plant, and it is rather creditable than the reverse that we are able to realize even half of the theoretic value of the fuel. If the demonstrator in the laboratory burned his carbon in the same manner he would not get an evaporation of fifteen pounds, either. Consider, also, the condition of the vessel in which the water is evaporated into steam; it could scarcely be worse than it is for economy and efficiency. The average steam boiler, unless carefully prepared for

experiment previously, is in no condition to boil water efficiently, and the devil-may-care methods of firing by the hands of a common laborer result in half of what is, or should be, coming to the man who buys the coal. This should not deter experimenters from prosecuting their researches further in efforts to bring out a furnace which is fool-proof, so to speak. Some of these are in existence now, but as they require skilled labor and attention, the steam user is slow to adopt them because he has to pay more for brains than for main strength and stupidity.

No one has more carefully investigated the thermodynamics of the steam boiler and its furnace than B. F. Isherwood; his analyses and connotations of what takes place in the furnace of steam boilers are not only exhaustive, but are very probable from a practical point of view. Although made nearly fifty years ago, his diagnoses will fit modern conditions as well as they did the crude boilers of his investigations. It is not difficult to formulate hypotheses upon any moot point, and suspend them by exceedingly tenuous ligatures to alleged problems met in practice; but when it is sought to apply such theories in daily work they are not found available. It is here that the vaticinations of Isherwood assist, for they are not only plausible but probable from the standpoint of the practitioner.

I quote a short excerpt from "Engineering Precedents," a work now out of print, which shows Isherwood's conclusions from an experiment with a tubular boiler. He found that different temperatures existed in the upper and lower rows of tubes and explains the matter in this way:—

> "We have seen that with the horizontal fire-tube boiler, the temperature of the heated gases emerging from different horizontal rows of tubes varies enormously—probably 300 degs. F. for the extreme top and bottom rows. Now, to what are we to ascribe this great difference? Is it to the fact that the gases find the easiest exit through the top rows, and that the calorimeter of these rows is sufficient to pass them with such facility as to rob the lower rows of their proper share, leaving them thus comparatively inoperative as heating surfaces? Or is it because the upper rows, in consequence of being enveloped in the total mass of steam developed by the furnaces, and by the lower rows lying beneath, are not in contact with enough solid water to reduce the temperature of the gases passing through them as low as the temperature of gases emerging from the lower tubes, which, lying in the steam produced in the furnaces only, are in contact with much more solid water and produce a higher economic evaporation from the more complete absorption of the heat of the gases? The latter is undoubtedly the true cause. The upper rows of tubes must necessarily be surrounded with a mass of mere foam, composed of water finely divided by and mixed with the steam generated from the lower

rows of tubes and the furnaces; in fact, nearly all the steam produced by the boiler has necessarily to pass between the tubes of the upper rows, displacing the solid water and replacing it with a soap-bubble like mass, possessing a far less heat-absorbing power. The result is that from the lower row to the upper one the tubes have a continually decreasing evaporating efficiency, owing to their absorbing a less and less amount of heat as we ascend, and, as a consequence, delivering their heated gases into the chimney at a continuously increasing temperature. . . . The economic evaporation of the tubes is then very greatly affected by their distribution, the maximum, *ceteris paribus*, being obtained from the fewest number of horizontal rows and with the widest spaces between the tubes.

"But this desirable arrangement can only be remotely approximated in practice, owing to the fact that the number of vertical rows is limited by the breadth of the furnace, and that, in order to place in this space the greatest number of these rows, the distance between them must be reduced to a minimum; at the same time the necessity of providing a proper proportion of heating surface and of calorimeter compels recourse to the maximum number of horizontal rows; and thus we finally obtain a boiler that satisfies the numerical proportions by ignoring physical laws and paying the penalty in a reduced evaporation."

This must suffice for direct quotation, but Isherwood suggests a remedy for the unequal distribution of heat in the tubes of the average tubulous boiler, which is to decrease the diameters of them from the bottom row upward; retaining the same number of rows, vertically and horizontally, but reducing the calorimeters in each horizontal row in the ratio of the squares of their diameters, the velocity and mass of the gases through them will also be reduced, and more time given for the absorption of heat. Although the heating surface *per se* is reduced, its efficiency is increased, so that the evaporation will be even greater than if all the tubes were of the same diameter throughout. The remedy for the unequal distribution of the heat is thus clearly pointed out, but I do not recall that it has ever been adopted by any one. Isherwood says that the diameter of the upper rows of tubes should be only two-thirds that of the bottom ones, and a space of 45/100 of their diameter between these last; by restricting the height of all the rows to 30 inches by making the aggregate calorimeter to one-seventh of the grate surface, and so proportioning this to the total heating surface measured on the *interior* of the tubes that it shall be as 1 to 28, we shall obtain the highest economical evaporation consistent with natural conditions.

"Natural conditions" applies directly and pertinently to boiler-room practice, and nowhere more appositely than in the burning of coal. Treatises upon the combustion of coal abound, but a man who can not read or write will make the most recalcitrant boiler furnish

steam, when another man who can accurately distinguish carbonic acid from carbonic oxide in a furnace has no steam. This is no disparagement of a knowledge of the laws of combustion, for all information that applies is of value at some time, but there is nothing within the scope of everyday engineering that is more baffling than these same laws.

All science is at fault at times, and though there is every reason present why a boiler should steam it simply will not. On such occasions every one takes a hand at the fires, but the result is the same—no steam, or only enough to keep three-quarters speed. A variety of causes combine to produce this condition of affairs; while slight in themselves, their aggregate effect is to paralyze the motive power for the time being, or until the deadlock is removed by a change of wind, or course, or by taking coal from another bunker. This last has been known to furnish a remedy for a sulky boiler as soon as the fires were cleaned and new ones started with fresh coal, showing clearly that the fuel had a bad streak in it. Marine and stationary boilers are afflicted in the way described; there are "good days" and "bad days" in the performance of both.

"Steam is king, long live the king" can scarcely be said in these days, for since the improvements in explosive engines its supremacy is seriously threatened. This is true of both large and small powers and plants, but especially of the former. Time was, not so very long ago, when steam launches were common on all the waters of the country, but there is not one now where there are hundreds of explosive engines which require no boiler. In establishments of every kind which require power of some sort, there are gas, or gasoline, engines in the place of steam; it would be rash to say that the days of steam prime movers are numbered, but it is within the facts to say that they have seen their best days. Gas engines of enormous powers are being installed daily, in Europe certainly, and will be in the United States sooner or later. In view of these facts it will be difficult for steam to regain its lost prestige; for consumers, when they find that it is cheaper to turn coal into gas and use it in an explosive engine than it is to burn it under a steam boiler and employ it in a steam engine, will promptly abandon the latter. For certain operations where steam is required for other purposes than power it will be poor economy to dispense with a steam engine, but in the widely extended use of gas, gasoline, and electricity, the radius of action of the steam engine has been much reduced.

SYSTEMATIZATION AND TOOL-ROOM PRACTICE IN A RAILWAY REPAIR SHOP.

By R. Emerson.

I. STANDARDIZATION AND GENERAL ORGANIZATION OF THE TOOL-MANAGEMENT SYSTEM.

The peculiar conditions present in the railway repair shop seem to have delayed, for a long time, the effort to extend there the economies of production which are taken for granted to be essential to the successful manufacturing establishment of today. One of the most interesting movements to the student of production engineering, therefore, is the present rapid extension of its principles and practice into this tardily opened field. Mr. Emerson has been intimately associated with some of the largest and most original work in this line. This gives the primary interest to his article. Its secondary interest lies in the fact that most—if not all—of the practice he suggests is profitably applicable to any shop large enough to have a tool room and a tool system. A second paper, of which this is yet more strikingly true, will follow in a later issue of this Magazine and will deal with the care and upkeep of the small-tool equipment.—The Editors.

RAILROADS are conducting a transportation business, not running manufacturing shops; none the less the laws of economy governing competition in commercial establishments play their part as certainly, if less evidently, where pressure of works-production rivalry is is not so immediate.

This article is to present only some of the practical advantages of a well worked out tool system, and cannot describe at length the mode of establishing such a system over an entire railroad and the functions of each branch. We shall therefore assume the road to run under a certain set of conditions:—it is a thousand or so miles long; it has several "divisions," each with its round houses and shops, one shop being the main one; it operates 500 or more locomotives. The road has probably grown by acquiring smaller properties, and consequently variety of "power," although there may be numbers of later locomotives in definite and few classes. Owing alone to the large proportion (and many of a given class) of locomotives passing through the main shop, the manufacture of parts tends to become reduced to definite practice, and standardization of equipment for this shop's division (and then for the road) is the next obvious step. Drawings of standard parts are made and these parts applied whenever engines passing through the shops require such renewal. New engines have standard parts specified in contract, these parts being made to company blue prints. Changed shop requirements and repair methods result from this new policy. With standard equipment it becomes possible to con-

centrate manufacture and get the cheapness of quantity-production. The tendency, then, is toward the regulation, by the engineer, of method of production as well as of design, and the carrying on of this production to this design under his supervision. The locomotive is built or repaired so far as may be in the shop by machine, the erecting floor being limited as far as may be to mere assembling. Such redesign must in a sense precede attention to the tool facilities; yet the methods of manufacture, tools used, and operations needful, should be considered parallel with the consideration of design; and design should be modified to accommodate method, as well as method devised to produce design. We are to consider relations of tool management to this condition of standardization of equipment, with consequent alteration of shop methods.

System as applied to one small tool room is a paying investment in the tools saved and in the facility with which the proper tools are available when wanted. System as applied to the tool regulation on the whole railroad pays not only to this extent, but to an even larger degree in the standards it is possible to establish, and in the decreased cost of production due to manufacturing locomotive parts by these standard tools on large scale, and accurately, so that they will fit in distant round houses. The methods suggested in this standardization of work (which is always dependent upon the tools) are closely akin to those now used in building locomotives in batches. Frame bolts are a case in point. In the locomotive works these are furnished in quarter-inch lengths, and in standard tapers. Holes are drilled and reamed according to these standards. All fits well. In the locomotive repair shops the customary method has been to ream out the old frame-bolt hole with standard-taper reamer, but without any given diameter. The bolt was then either completely forged up from the rough and cut off and turned to size, or else was so turned and fitted from a blank size in stock. In either case much individual labor was needed on each bolt. The new method would call for a series of diameters of these taper-bolts varying by 1/32 inch. An engine passing through the shops would have all her frame holes reamed out to the size next larger than the one previously used. This could be done with a standard shoulder reamer of high-speed steel, the resulting hole perfectly accommodating the bolts in stock. Such a stock of bolts from one of the large railroad systems in this country represented an investment of less than $1,200. Needless to say the interest on this sum and on the somewhat more expensive tools was insignificant compared to the greater expense of putting in bolts in the old individual

way. It is the province of the tool man to care for these reamers and to keep them to standard. In order to do this properly, a tool system is needed whereby it will be impossible for a man to have one of them in his possession long enough for him to wear it below standard size.

Railroads use tools of all kinds; it is difficult to say whether the investment in small tools or in machine tools is greater. While the former are individually cheaper, they may be collectively more costly.

One of the most important features of small-tool equipment is the air-tool service. These tools for the money invested in them do giants' work, but on account of the severe strains to which they are put they suffer frequent disorders. Unless this branch of the service is rigorously supervised, constant trouble and vexatious delays will result. From figures in my possession I find that the maintenance and repair charges on pneumatic tools range from 60 per cent. to 90 per cent. per annum on the purchase price of these tools, without counting the depreciation and interest charges, which in the case of tools with life so short as these are very high—I should say, combined, an additional 100 per cent. In fact, this maintenance and repair cost, together with the purchase price of the tool, will average somewhat above $200 per annum, this figure applying equally to motors and hammers. As it is false economy to do work by hand that can be done by air, and as there is much work that can be done more conveniently and cheaply with portable air tools than with stationary machine tools (such for instance as chipping chamfers on locomotive frame jaws in place, or the miscellaneous drilling and tapping on boilers), the larger the number of air tools engaged in productive work the cheaper the output costs. And yet in a shop where a hundred or more such tools are in use (the figure of one motor to every ten men on the total pay-roll of the shop, or rather one machine for every six men engaged in boiler or erecting work, is a safe one) the expense amounts, of course, to a great deal, and most careful supervision amply pays for itself. As in the case of arrangement of tool rooms, the distribution of air-tool equipment will vary according to circumstances. A good practice is to allot a fixed number and style of machine to each gang of men, providing lockers for the storage of these machines at night, and holding the gang foreman—or he holding one of his men—responsible for the proper keeping of these machines. Of course there must be a dozen or a dozen and a half extra machines in the tool room for special use. At the end of each week all motors and hammers are turned into the tool room, where they are thoroughly inspected, cleaned, tested, and if needed, repaired and adjusted. It may be mentioned in this connec-

tion that it will be difficult to find a careful man with sufficient skill to keep these delicate machines in first-class order. It may also be pointed out that such a well defined system of maintaining air-tool efficiency, as opposed to the common method of effecting repair only when it is absolutely necessary, involves for its most economical working the standardization of this pneumatic equipment (that is, limitation to only five or six sizes or types of machine) and the keeping in stock of all spare parts. It will be found that many motor parts can be made much more cheaply than they can be bought from the manufacturer, and often design may be altered or simplified right in the shop.

This system, while it seems to cost something in the fact that one skilled man at least is engaged in nothing else but air-motor repair, is in reality not only cheaper in its supervision cost, but also is a great deal less expensive than when the spare parts are purchased or motors sent to manufacturers for repairs.

One large railroad company had its pneumatic-tool account rising steadily for the past five years, *averaging* over $15,000 per year for new tools, and material and labor repair charges alone. This account had not been systematically looked after, tools being battered around the shop till it was no longer possible to effect simple repairs and adjustments, when they were sent to the manufacturers for thorough overhauling and replacement of parts. The practice obtained of men seizing what motors they could lay hands on and using them, often carelessly, until the machines would no longer give good service or run at all. There was practically no one to raise the question except the man using the machine or the shop foreman who was interested in the output of the work, or the tool-maker who was delegated to make repairs—each of these men being powerless to effect any reform or establish any system or incite any interest in the matter of properly handling these tools as a general proposition. But when the master mechanic himself awoke to the importance of this matter, because on the one hand of the curtailment of his requisitions for additional air-tool equipment, and because on the other hand of a long-drawn howl on the part of the shops for increased facilities in this direction, he set a special apprentice to work to see what could be done and saved by means of an efficient system. One similar to that above outlined was slowly evolved and installed; the net result of this system of holding men and foremen responsible for machines definitely assigned to their charge, together with the enthusiastic co-operation and ingenious handling of the repair question by the tool-room foreman, was a reduction in cost to less than $5,000 per year, not counting interest, de-

preciation, and fixed charges. This saving represents the interest at 4 per cent. on $250,000.

These figures take no account of the saving of the men's time due to increased use of air tool equipment and more efficient performance of same in service, as these savings being indirect though great, could not be determined. There was, however, a vast difference noted. Whereas formerly there were daily complaints and quarrels between the men, clamoring at the tool room, bothering of foreman, chasing about the shop by the half-hour in search of motors, the smoothness of operation of the new system and the fact that it was answering the requirements placed upon it were evident from the ceasing of the uproar of previous times and from the satisfaction which all concerned took occasion to express when asked respecting the change.

The tool room has been treated so far as simply a convenience to the shop, but it may be far more. It may instil the very breath of life into shop operative economies; it may be the origin of manufacturing methods upon whose practicability and cost-saving features the success of the shop as a commercial proposition rests. Of course, one must have a man, one with large ideas, experience, and inventive fertility—presumably an expensive man—at the head of this tool system. He will see to it that the tool room furnishes templets, jigs, and tools for the rapid production on large scale of standard parts, before it is forced to do so by the reiterated demands of some of the more progressive foremen; in other words, that the tool room shall be leading the shop. The tool accounts on western American railways vary from about $100,000 to $500,000 per year, and must reach over a million on such systems as the Pennsylvania. This sum sounds expensive for a mere incidental to locomotive maintenance; and it *is* expensive—extravagantly so—unless it is intelligently spent. Should this amount, however, be doubled, three or four times the additional expenditure could be saved in cost of locomotive repairs. It can be authoritatively stated that when tool expenditures are well systematized, the efficiency of the system as a manufacturing output cheapener is not only manifolded, but the actual cost of operating the system itself can be materially reduced—from 12 per cent. to 20 per cent. in cases under my own observation.

A few samples of the way this inventiveness can help not only the central shop but the whole road may here be given. It was calculated that if it were required to lay out more than one side-rod, it would pay to lay out a sheet-iron templet, the latter to be used in laying off the two or more rods instead of measuring these up individually. The

cost of the templet was therefore a credit rather than a debit sum. Similarly for cylinder-head templets and drilling plates for front ends and flue sheets. This for the individual shop. For the whole system the tool room may standardize the manufacture and application, as noted above, of frame bolts, or of knuckle-joint pins, or staybolts. The methods in the case of the last two items were very similar. For the pins, standard "taper shoulder" reamers were provided for each size or class of pin, the number of such classes being reduced to a minimum—in the case I have in mind, four. Each class or nominal size was provided in four diameters varying by 1/16 inch. All new work was reamed to the first and smallest diameter, and at each subsequent overhauling to the next larger diameter. The use of these shoulder-reamers and their distribution to every shop and roundhouse of any size on the railroad system made possible the manufacture of these pins by turret-lathe methods, to standard diameters and in large quantities, and the distribution of these pins as stock to the points where they would be needed, thus saving entirely the expensive method of turning each pin separately as occasion required and time pressed. Staybolts also are made very accurately to standard diameters varying by 1/16-inch and 1/32-inch, and to various lengths, sample staybolts of each lot being accurately gauged for size by limit thread guages. Stock of these bolts is distributed in similar fashion to that of frame bolts and pins, accurate fitting of the staybolts being insured by the maintenance, by frequent inspection throughout all the shops, of standard size of staybolt taps. When this manufactured stock of staybolts is first furnished a complete canvass of every staybolt tap on the road is made in person, by someone competent for the job. These taps are permitted to be used only while they are within 3/1000 of size, all others being scrapped. Small V limit gauges are provided at each point for the local tool man to test his taps for size. Thus staybolts manufactured centrally may be applied anywhere.

Not only must these methods be devised and the prejudices of local foremen with their own ideas, be overcome in their introduction, but also the man who has originated and carried out these plans must follow them up unceasingly so as to keep up the cheapness of work once attained. This man whom we have placed in charge of the tool arrangements over the entire railroad will be the most expensive man of all, yet he will justify his salary not only by the savings he effects in operative costs, but also in many indirect ways. He can conveniently supervise all requisitions for tools of every kind, machine tools included; with his expert knowledge he can distribute tools among

the various shops, and in fact designate the character of the work and its distribution in the most effective way; he can check the accumulation of surplus stores of machined parts; he can test and report on all new processes that come up—such as determining whether, where, and how to use this or the other brand of high-speed steel; whether shoes and wedges should be planed or milled; whether piston rods should be finished on the lathe or on the grinding machine; to what extent it pays to go into electric-motor driving.

Tools produce the work; therefore tools determine cost. And unless you have an able man as the keystone of the organization of men who are to use these tools and produce the work (I refer to my general-tool man), nothing will result from lifeless system alone. But just as the successful application of such system depends on the man, so, too, does the highest manufacturing efficiency depend upon the following cardinal principle:—that all tools, of whatever nature, should be worked to their maximum effective limit. This necessity is a transient aspect of our rapidly changing arts—an aspect which is likely to continue for the next generation or so at least. Owing to the rapidity with which we are gaining insight, not only as to the nature of materials but also as to methods for working these up most usefully, practice of today is so far refined on practice of yesterday that the art of yesterday deserves to be lost. What is true of steel bars forged into cutting tools will apply with equal force to complicated machines having an effective working limit. If men and work were pushed to maximum production it would probably pay to scrap a shop's entire machine-tool equipment every two years; it would certainly pay to do so every five years; and this because, if worked to their limit of capacity, these tools should turn out in this short time a product many times their own value, thus quickly paying for themselves in usefulness, as quickly outwearing that usefulness by intensive production, then giving place to newer and later tools with a still greater effective-production limit. The time may come when processes will be so well worked out that it will pay to spare the machine in pushing the work; but that is still far off, and we of the present are concerned with this different set of conditions. What is true of these largest groups of machine tools is even more true of the small hand tools; the faster these can be worn out—not broken—the better it speaks for the way shop work is pushed. The man at the head of this tool systematizing should not hesitate to substitute a smoothly working idea for an inefficient mechanism of metal—should, while constructive in plans, be destructive of what fails of requirements when he deals with machines.

EDITORIAL COMMENT

IN the First Labor-Saving Number of this Magazine, which appeared in March last, we pointed out that "there is no act of manufacture, no stroke of construction, no detail even of household work, in which at some stage labor-saving does not play a vital part." And there is no line of human activity in which this is more apparent than in the movement of materials. It is almost staggering to measure up how large a proportion of all the work of the world is included under this head. The navvy in the ditch—the machinist at his lathe—the artist at his easel—each is engaged in moving certain predetermined materials to or from certain exact positions. Throughout almost this entire range, the skill of the inventor and the engineer has found embodiment in devices for lightening manual effort, and enabling the worker to multiply the value of his production by concentrating his skill upon his higher functions.

Mechanical transport, therefore, furnishes the widest range of expression of labor-saving machinery; to it in its manifold applications, and especially in those which apply to mining and metal working, we shall devote the next number of THE ENGINEERING MAGAZINE. Our issue for January will be the Third Labor-Saving Number, completing the series proposed last spring.

* * *

THE Panama Canal is the largest concrete proposition—the largest single example of the application of mining and mechanical handling and transport machinery—now before the world. Prof. Wm. H. Burr, member both of the Isthmian Canal Commission appointed by President McKinley in 1899, and of the present Panama Canal Commission charged with the plans and execution of the work, will occupy the leading place in this special number with a concise account of the actual condition of the undertaking—that is, the legacy of work, *materiel*, and plans and surveys received by the present commission from former ones and from the French company—and the nature of the work now being carried on upon the Isthmus. It will clear away many misapprehensions which have been raised as to the facts of the case, and give a definite idea of the basis upon which the great project now stands.

* * *

IN a leading article elsewhere in this issue, Mr. Haskell discusses the important subject of railway accidents in the United States, and rightly attributes many disasters to the tacit disregard of rules and methods of signalling. Any one who is at all familiar with the operation of railroads in the United States must acknowledge the truth of the charge which he plainly makes, namely, "that the admirable rules for the government of employees are habitually disregarded;" but the very admission of the truth of this statement is also an admission of the inadequacy of the mechanical safeguards which are at present in use.

The only way by which the disregard of signals and rules can be prevented is by making it physically impossible. The engineer must have no discretion

as to whether he will stop or run past a block signal; he must be stopped by a mechanical device, the release of which is beyond his control.

The introduction of such devices is not difficult nor impracticable, and there are numerous methods by which they may be effectively employed. The derailing switch is well known, and no engineer who realizes that the passage of a block signal means the ditching of his train will willingly run into such a certainty. This, however, is not sufficient, as the engineer may not even realize that the signal is set against him. The setting of the block signal should also set his brakes automatically for him, if he disobeys the warning, and hold him ignominiously stalled until he is released by the opening of the block. The rear protection may be equally controlled by setting a trip for the operation of any following train which may approach within the danger limit, and thus the element of discretion be wholly elimated.

* * *

In a certain large city there occurred, several years ago, a number of accidents upon passenger elevators, these being clearly traceable to the practice of the operators of opening and closing the doors while the car was in motion. Like the current methods of train operation, the rules requiring the car to be brought to a full stop at the floor before the door was opened, and also requiring the closing of the door before the car was started, were generally ignored, and the results were apparent in numerous and fatal casualties.

By the passage of a suitable ordinance it was made obligatory to equip all passenger elevators with interlocking stops, which rendered it impossible to start the car while any door was unhooked, the hooking of the door releasing the operating lever in the car, and the presence of the car exactly opposite a given floor being necessary before the door could be unhooked. At first there was some delay in the service, but in a very short time the operators became as expert as they had formerly been careless, and the cause of the accidents was entirely removed.

* * *

The delegation of responsibility to employees is a matter of great importance, especially where human safety is involved, and it cannot be entirely removed; but it is entirely practicable to limit it to positions where it can be exercised without fear or favor.

In the case of train operation, the modern signal systems are designed to place the element of responsibility upon the operator in the signal tower, and experience has shown that this is all right. To permit disobedience to the signals to nullify the safety element in the whole system is both a crime and a blunder, and until the possibility of the disregard of the signal by the engineer is removed, no rules, however carefully devised, can be of avail. The passage of a block signal by a train should be made mechanically and physically impossible, and in like manner should the approach of a train in the rear be mechanically limited to a determinate distance.

* * *

The promised reforms in the New York post office are of far more than local importance, for more reasons than the obvious one that the leaven introduced there might be expected to spread to the other large offices of the country. New York has long been the *entrepôt* for most of the foreign mail of the country; with the rise and rapid growth of the custom, especially among the large engineering manufacturers, of establishing a chief sub-office or sales office there, even though the main plant and management be centred elsewhere, New York has grown in importance as an exchange or clearing house for domestic business communi-

cations. Anything facilitating the movement in the New York office quickens the whole network.

To an observer of conditions as they are, the most apparent need is greater fluency of movement within the New York post office. Its external exchanges, especially its long-distance exchanges, seem well arranged. But the internal postal communication is grotesque in its inadequacy. It is rare indeed that a city letter is received by the addressee the same day it is mailed, and such a thing as exchange of original communication and reply within the business day, by use of the mails, is hardly even thought of. In fact, most business houses place so little dependence on the prompt carriage of their local letters by mail that everything except urgent matter (which is entrusted to private messenger) goes until evening and is dumped into the office with the out-of-town correspondence. It is more convenient so, and reaches its destination just as soon—i. e., the next morning. And yet that destination may be only a few blocks away. If the contemplated reforms should take the direction of giving New York some such an internal postal service as London enjoys, for example—say an average interval of three, or even four, hours from the mailing to the delivery of a city letter—the immediate result would be a more even distribution of the mail received in the drops throughout the day, a marked relief from the overwhelming influx during the evening hours, and a most valuable gain in time to correspondents all over the United States.

* * *

THE iron and steel industry seems to be almost capable of outracing the vision of its prophets. To one who notes the amazing swiftness of its rise, there must occur at times the fear expressed in these pages by Mr. J. S. Jeans, something more than four years ago—the fear of the "difficulty of finding adequate supplies of cheap and suitable iron ores." The figures which excited that fear in the mind of Mr. Jeans showed a total production of pig iron in the world reaching 37,300,000 tons in 1899. The summary just published in the statistical report of the American Iron and Steel Association gives the corresponding figures for 1903—only four years later, and a year of general though not severe depression—as 46,420,000 tons.

An increase of this magnitude is impressive enough; it is nearly 25 per cent. in four years. The 9,000,000 tons we have added to our yearly manufacture since 1899 is a quantity greater than the total annual output of iron in the world forty years ago. But even more significant is the distribution of the present industry. Almost exactly half of the increase comes from the furnaces of the United States. Nearly a fourth is supplied by Germany. But Great Britain, once iron-master to the world, appears in the column of decrease. She has dropped to third place, furnishing but 18.98 per cent. of the total output, while Germany makes 21.73 per cent., and the United States 38.80—almost as much as England and Germany together.

Another extremely interesting movement shown by the estimates is the acceleration of the replacement of iron by steel as the great material of engineering construction. Twenty-five years ago, but one-fifth of the pig iron produced was converted into steel, or about 3,000,000 tons altogether in 1878. Fifteen years ago, the proportion made into steel had risen to nearly two-fifths of the total. In 1903 it was more than three-fourths—nearly 77 per cent. Undoubtedly the substitution of steel for iron has gone too far in some directions One of the movements to be expected within the next few years is the partial revival of the manufacture of soft iron. But of that we shall have more to say at another time.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

MOTOR-DRIVEN MACHINE TOOLS.

A DISCUSSION ON THE INDIVIDUAL OPERATION OF MACHINE TOOLS BY ELECTRIC MOTORS.

Journal of the Franklin Institute.

THERE has been so much said and written about the advantages and deficiencies of the electric motor for the direct driving of machine tools, that it has well been felt that the whole matter should be permitted to work out its own salvation, so to speak, at least to a limited extent, and permit constructors and users to profit by the lessons of experience.

At a recent meeting of the Franklin Institue there was recently held a discussion upon the use of electric motors for driving machine tools, and from a report of this discussion, in the *Journal* of the Institute, we abstract some of the leading points elicited.

The discussion was opened by Mr. Charles Day, who, after a brief historical review, showed that the use of independent electric driving represented at least 350,000 horse power in the United States alone, this being ample evidence of the extent to which various systems had come into use. Discussing the matter from the machine owner's viewpoint, Mr. Day said:

"Such factors as independent location of machines and better facilities for handling work are interesting, but are they worth while? In other words, is the constant-speed individual motor drive a paying investment? Ease of handling and speed control are terms that one constantly hears; but is the additional expenditure necessary to obtain them justified from a consideration of dollars and cents? Some concerns have gone ahead blindly, simply accepting the statement that the individual drive is the proper thing, and in almost every instance the resulting equipments do not begin to possess the possibilities that they should, and in many cases are not yielding a return to justify the expenditure.

"Until it is fully understood that the words 'a motor-driven tool' need not necessarily imply high efficiency, the advantages made possible by the use of the best types of such apparatus will not be gained. I feel that I cannot dwell too long or forcibly on this point. The tool steel, the machine, the motor, the man, are all but means to an end. Let us always first bear in mind this end. Machinery designed to fulfil the conditions of economical production is the machinery that will be purchased, not only once, but repeatedly, and that is what is needed to perpetuate this work. We can all point to large motor-driven equipments—usually the first installed; will they be duplicated or extended? Only if it can be clearly shown that a proper return has resulted. As stated above, a number of the largest equipments do not possess the possibilities anticipated; in others they may be present but of no earning value, on account of lack of intelligent direction of work. This is equally true of belt-driven machines; but the motor drive, with its greater possibilities, should only be adopted as the result of a definite need.

"The shop manager who does not see clearly the inability of a belted tool to attain maximum output, and the reasons, cannot hope to gain appreciably by purchasing a motor. Let me repeat, a motor-driven

shop does not insure low cost of production any more than efficient guns can guarantee a naval victory."

Mr. Day compared the adaptation of electric motors to machine tools twelve years ago with recent examples, showing two lathes, originally designed for belt driving, but changed to be operated by electric motors. In the case of the earlier machine the motor ran at a uniform speed, the speed changes of the lathe being effected by a nest of gearing; in the second case the motor provided for a portion of the speed changes, these being extended by the use of gearing. Better results are obtained when the entire machine is designed for the use of electric driving, and undoubtedly this feature will be taken into account by machine-tool builders in the immediate future.

An important element for consideration is undoubtedly the choice between motors of uniform speed and variable-speed motors. The latter are the more expensive, both in installation and in operation, but until some entirely effective speed-varying device is put on the market it is probable that a portion of the speed changing will be done in the motor.

In continuing the discussion, Mr. F. B. Duncan said that it was desirable to take cognizance of the two great factors involved —the financial and the human.

"First, Does it pay?

"Second, How can we convince people that it does pay?

"The first question has been well threshed out, and while many foolish investments have been made in motor equipment (as foolish investments have ever been and will continue to be), yet, on the whole, electrically operated machine tools have paid well.

"Better placement of tools, especially the larger ones. The operation of powerful portable apparatus for use on the very largest work. Better crane service due to the absence of belts. The inestimable boon of the electric crane itself. Better light. Less dirt. Less danger to employees. Lighter overhead construction necessary in new factories due to non-existence of countershaft, etc. Fuel economy in many (but not all) instances; and last, and greatest of all, abundance of power to pull a cut of the most generous proportions at the highest speed permissible with the new high-speed tool steels."

The most important thing to be done at the present time is to impress upon tool builders that it is not sufficient to buy a motor and hitch it up to a tool originally designed to be driven by belting. What is needed is a complete re-design of present machine tools with motor operation alone in view, giving an entire line of machine tools designed electrically and mechanically for the production of the greatest amount of work in the shortest possible time.

"The tool builders and electrical men may well take a leaf from the experience of the automobile manufacturers. Until the latter abandoned standard motors, engines, bodies and gears, and evolved, appropriated and combined types made necessary by the exigencies of the case, no substantial progress was made; but since they have evolved new types of engines, motors, running gears, bodies, etc., the industry has advanced by leaps and bounds until it is one of the marvels of this wonderful century.

"The motor-driven machine tool will make a similar advance as soon as a firm is found with nerve enough to break away from old traditions, and put a few record-breaking tools on the market whose electrical and mechanical design is of the twentieth century.

"The requirements are simple and severe: machinery heavy and stiff enough to stand the maximum cut the work will stand, equipped with a motor designed to give the proper speed variation, and powerful enough to pull the maximum cut, built into the machine as an integral part of same.

"A few tools of this type set up alongside of belt-driven apparatus will soon convince the most skeptical that motor drive pays, for such machines will forge ahead of our present apparatus, much as a high-speed automobile distances a horse and buggy.

"We may also look forward to the time, not far ahead, when recording instruments on the tools will give the superintendent a check on production and on the individual operator, that will enable him to keep track of the 'personal equation' in the shape of lazy workmen in a most accurate and impartial manner, with corresponding benefits to the output of his tools, the dividends of the stockholders and the pay envelope

of the diligent and intelligent mechanic."

Probably the judicial views of Professor Elihu Thomson upon this important subject may well be given, emphasising, as they do, the importance of the exercise of the careful judgment of the able engineer upon the merits of each case.

"My general opinion is that there is no hard-and-fast rule which can be laid down, everything depending on the conditions of use of the machine tools. In some cases the group drive will undoubtedly hold its own, and perhaps in other instances the belt, counter and line shaft will be retained. The individual drive is likely to continue to replace the older forms, particularly for the larger tools, and for those kept in active service at maximum output. The accumulation of data on the subject is gradually becoming such that it will be possible before long for competent engineers to determine the desirability or undesirability of resorting to individual operation by motors.

"A modern works of any extent now requires its engine-dynamo in power-house to be conveniently located, with connecting lines from which power is obtained from electric motors, sometimes to drive line shafting, serving groups of machines more or less extended, and at other times driving certain machines individually.

"The case of each factory or workshop is, it seems to me, one which needs to be considered by itself, with a careful estimation of all that goes to increase the economy of the operation."

LONG DISTANCE TRANSMISSIONS WITH CONTINUOUS CURRENTS.

THE POSSIBILITIES AND ADVANTAGES OF CONTINUOUS ELECTRIC CURRENTS AT HIGH VOLTAGES FOR POWER TRANSMISSION.

Le Génie Civil.

IN the course of the development of the application of electricity as a means of the transmission of energy, the necessity for employing high voltages soon appeared. One of the principal elements of cost is that of the metallic conductors, usually of copper, and it is only by the use of high pressures that the diameter of the line wire, and consequently the cost for material, can be kept within commercial limits.

Although, until recently, the continuous current has been principally used in electric motors, the alternating current, at high voltages has been employed for the line transmission, the transformation being made at the distributing stations by the use of rotary converters. With this arrangement pressures of 40,000 to 60,000 volts have been successfully employed, and in some cases, notably in California, distances of 150 to 200 miles are traversed by alternating currents transmitting as much as 40,000 kilowatts of electrical energy.

There are various drawbacks, however, to the use of alternating currents, the alternating action producing certain secondary phenomena, connected with capacity and inductance, tending to reduce the efficiency and the distance to which power can be satisfactorily transmitted. At high voltages also the striking distance of the current across the gap between the line wires, and the overcoming of the resistance of insulators constitute certain limits to the employment of the still higher voltages which might otherwise be desirable.

For these reasons it has been thought possible that a return to the continuous current might be a subject for consideration, and hence a number of experiments which have recently been made by the Compagnie de l'Industrie Electrique, of Geneva, are of immediate interest. From an account in a recent issue of *Le Génie Civil* we make some abstract of these investigations, which are probably but the first of other more extended researches.

At the present time the continuous current is not employed in actual service at pressures higher than 25,000 volts. Experience has shown that with the continuous current, using a line of 30 kilogrammes of copper per electrical horse power at the terminus, and allowing a loss 10 per cent., a pressure of 42,000 volts is required for a distance of 100 kilometres, or a little more than 62 miles. Unless, therefore, such voltages can be commercially produced and maintained the continuous current is not

available, and it is certain that the demand is for transmissions of greater length than 60 miles, rather than for shorter ones.

Although continuous-current generators of the Thury type may be constructed to generate currents of high voltages by the introduction of condensers between the sections of the armature, the experiments at Geneva were made by connecting three dynamos in series, a pressure of 70,000 volts being thus readily attained. The current generated being 1 ampere, a power of about 70 kilowatts could be developed, and comparative trials were made under these conditions with an alternator of 75 kilowatts, and a frequency of 50 cycles, to ascertain the relative losses. These trials were made to determine the distances at which discharges through air took place, the insulating resistances of various line insulators of accepted design, and the behaviour of various insulating materials.

So far as the sparking distances are concerned, these naturally depended much upon the nature of the terminals, and experiments were made with terminals consisting of points, balls, and plates in various combinations. The distances, while irregular, were in all cases much greater for the alternating than for the continuous current, the ratio being from 1.5 to 2 times greater. It follows that line wires for use with continuous currents may be placed nearer together with less liability of discharges than is the case with the alternating current.

The most important portion of the trials appeared in connection with the behaviour of insulators. These were made upon a number of commercial forms of porcelain insulators, mounted as for regular service, and tested, both in the laboratory and during a fine rain in the open air. The results are given in tabulated form, with drawings showing the construction of the various insulators, and some very interesting conclusions appear. In all cases the insulation is far better maintained with the continuous than with the alternating current. Broadly, the insulators were found to stand about double the voltage with the continuous current than with the alternating, and in the former case there was little or no crackling or brush discharges until the limiting voltage was almost reached.

With the alternating current, on the contrary, there was evident loss by discharges as the breaking-down pressure was approached, and a corresponding noise. In nearly all cases the insulation failed by discharge taking place between the wire and the pin support, without perforating the porcelain. With the best types of multiple petticoat insulators, pressures of 60,000 volts and over were sustained without difficulty.

Some experiments were also made upon various insulating materials, and in every case the greater resistance to the continuous current appeared, so that there is little doubt that, so far as insulation is concerned, the line losses by leakage may be materially reduced by the substitution of the continuous for the alternating current.

It has been maintained that with the continuous current an electrolytic action takes place, and that this will lead to a gradual disintegration of the material of the insulator, or at least such changes as will materially diminish its insulating properties. It has been found, however, that this action cannot take place except in the presence of free moisture in the body of the material, a condition which it is entirely possible to prevent, and which, indeed, cannot exist in such materials as porcelain, mica, etc. In the case of the electrical machinery itself, the moderate heat which appears in dynamos, motors, etc., effectually prevents the accumulation of moisture.

The general conclusions which may be drawn from these experiments are, that it is entirely possible to use the continuous current at voltages sufficiently high to enable it to compete with the alternating current for long-distance power transmission, and that by the use of the direct current many of the phenomena which limit the commercial uses of the alternating may be altogether avoided. When it is understood that the continuous current at 22,000 volts pressure is even now successfully used in transmitting 5,000 horse power between St. Maurice and Lausanne, a distance of 60 kilometres, it will be seen that there is encouragement for extending both the voltage and the distance. It is to be hoped that additional experiments will be made and that this important subject may be further developed.

RAPID TOOL-STEELS.

RECENT DEVELOPMENTS IN THE MANUFACTURE AND APPLICATIONS OF HIGH-SPEED TOOL STEELS.

J. M. Gledhill—Iron and Steel Institute.

SEVERAL months ago we reviewed in these pages a paper by Mr. Gledhill, presented before the Coventry Engineering Society upon modern rapid-cutting steels, and now we have a fuller and later treatment of the same subject by the same author in the form of a paper presented at the New York Meeting of the Iron and Steel Institute.

Mr. Gledhill, while speaking mainly for the steel made by Sir W. G. Armstrong, Whitworth & Co., discusses the subject broadly, and without limiting himself to any proprietary matters. He briefly reviews the development of high-speed steels, and calls attention to the interesting fact that the "wootz" of India, and the famous Damascus steels, are known to have contained tungsten, so that a latent high-speed steel may be said to have existed centuries ago, and only a knowledge of the proper method of tempering it was lacking.

The most interesting portion of Mr. Gledhill's paper is the summary of the results of experiments with steels of various compositions, these showing practically how the best modern high-speed steels are made.

The high-speed steels of the present day are combinations of iron and carbon with—

(1) Tungsten and chromium,
(2) Molybdenum and chromium,
(3) Tungsten, molybdenum and chromium.

These present many interesting varieties, and offer a wide field for research. The author has made a large number of experiments to ascertain comparative cutting powers of steels produced by varying proportions of these elements, and it may be interesting to briefly state the results of some of those investigations.

Influence of Carbon.—A number of steels were made with the carbon percentage varying from 0.4 per cent. to 2.2 per cent., and the method of hardening was to heat the steel to the highest possible temperature without destroying the cutting edge, and then rapidly cooling in a strong air blast. By this simple method of hardening it was found that the greatest cutting efficiency is obtained where the carbon ranges from 0.4 per cent. to 0.9 per cent., and such steels are comparatively tough. Higher percentages are not desirable because great difficulty is experienced in forging the steels, and the tools are inferior. With increasing carbon contents the steel is also very brittle, and has a tendency to break with unequal and intermittent cutting.

Influence of Chromium.—Having thus found the best carbon content to range from 0.4 per cent. to 0.9 per cent., the next experiments were made to ascertain the influence of chromium varying from 1.0 per cent. to 6.0 per cent. Steels containing a low percentage are very tough, and perform excellent work on the softer varieties of steel and cast-iron, but when tried on harder materials the results obtained were not so efficient. With an increased content of chromium the nature of the steel becomes much harder, and greater cutting efficiency is obtained on hard materials. It was observed with an increase of chromium there must be a decrease in carbon to obtain the best results for such percentage of chromium.

Mention may here be made of an interesting experiment to ascertain what effect would be produced in a rapid steel by substituting vanadium for chromium. The amount of vanadium present was 2.0 per cent. The steel readily forged, worked very tough, and was hardened by heating to a white heat and cooling in an air blast. This tool when tried on medium steel stood well, but not better than the steel with the much cheaper element of chromium in it.

Influence of Tungsten.—This important element is contained in by far the greater number of the present high-speed steels in use. A number of experiments were made with the tungsten content ranging from 9.0 per cent. to 27.0 per cent. From 9.0 per cent. to 16.0 per cent. the nature of the steel becomes very brittle, but at the same time the cutting efficiency is greatly increased, and about 16.0 per cent. appeared to be the

limit, as no better results were obtained by increasing the tungsten beyond this figure. Between 18.0 per cent. and 27.0 per cent. it was found that the nature of the steel altered somewhat, and, instead of being brittle, it became softer and tougher, and while such tools have the property of cutting very cleanly, they do not stand up so well.

Influence of Molybdenum.—The influence of this element at the present time is under investigation, and our experiments with it have so far produced excellent results, and it is found that where a large percentage of tungsten is necessary to make a good rapid steel, a considerably less percentage of molybdenum will suffice. A peculiarity of these molybdenum steels is that in order to obtain the greatest efficiency they do not require such a high temperature in hardening as do the tungsten steels, and if the temperature is increased above 1000° C. the tools are inferior, and the life shortened.

Influence of Tungsten with Molybdenum.—It was found that the presence of from 0.5 per cent. to 3.0 per cent. molybdenum in a high tungsten steel slightly increased the cutting efficiency, but the advantage gained is altogether out of proportion to the cost of the added molybdenum.

Influence of Silicon.—A number of rapid steels were made with silicon content varying from a trace up to 4.0 per cent. Silicon sensibly hardens such steels, and the cutting efficiency on hard materials is increased by additions up to 3.0 per cent. By increasing the silicon above 3.0 per cent., however, the cutting effect begins to decline. Various experiments were made with other metals as alloys, but the results obtained were not sufficiently good by comparison with the above to call for comment.

The composition of the "A. W." steel, as given by Mr. Gledhill, may be of interest, this containing 0.55 per cent. of carbon, 3.5 per cent. chromium, and 13.5 per cent. tungsten.

The difference in the behaviour of carbon and high-speed steel is both interesting and curious. An ordinary carbon steel of 1.20 carbon, when heated and quenched, becomes exceedingly hard, but loses this hardness with the increase in the temperature of friction in use, this limiting definitely the speed at which it may be used. The high-speed steel, having been raised almost to the melting point in hardening, can withstand correspondingly high friction temperatures before sensibly losing its hardness.

The theory of this fact, according to Le Chatelier and Osmond, is involved in that of the temperature of transformation.

"Steel undergoes at 700° C. a change of nature which has been studied in all its details by M. Osmond. This transformation, like a great number of chemical transformations, takes place with more or less considerable delay according to certain other circumstances. *When heating*, the transformation will take place above 700° C.—for example, from 750° to 800° C., according to the rapidity of heating. *When cooling*, below 700° C. the quickness with which this transformation takes place at a given temperature, is governed by a general law of chemical phenomena, and this rapidity is so much the greater (1) As the absolute temperature in question is highest; (2) As it is at its greatest distance from the point of transformation."

The influence of tungsten, chromium, molybdenum, and other elements is to retard the transformation at the critical point, as compared with ordinary carbon steels.

In preparing the high-speed steel for use, Mr. Gledhill calls attention to the importance of annealing it thoroughly before working into bars, this relieving all internal strains, and rendering it sufficiently soft for machining into shape, as for milling tools, drills, taps, etc.

The necessity of heating the tool to a high temperature, in order to harden it, has given rise to various plans for accomplishing this operation under satisfactory control. Mr. Gledhill describes various methods, including the use of muffle furnaces, gas stoves, and ordinary shop methods, but evidently prefers the use of electricity as most convenient and controllable. One method consists in the use of a solution of potassium carbonate, the tank and the tool forming portions of an electric circuit which is completeed when the tool is dipped in the solution. The passage of the current sets up an intense heat on the immersed part of the tool, and the switching off of the current permits rapid cooling without removal from the solution.

The electric arc has also been used for

heating the tool, this being especially useful for the production of local heating at desired points. Electric heating has been found most useful for annealing certain portions of high-speed steel tools, enabling the interior of milling cutters, gear cutters, hollow taps, or reamers, and the like, to be made soft and tenacious without impairing the cutting qualities of the exterior.

Mr. Gledhill gives some interesting examples of the gains effected by the use of high-speed steel, showing a gain of five to one in turning armor-plate bolts, not including the saving due to the possibility of making the bolts from the round bar instead of requiring expensive forgings. Other examples are given, but the operative gains from the use of modern steels are now so well known that it is almost unnecessary to mention them. One illustration may be given, however, as remarkable, namely, the milling of large hexagonal nuts for armor-plate bolts, these nuts, for 3⅛ bolts, being produced so economically that the cost of making 12 such nuts is less than the cost of forging one nut under the old method.

IMPROVEMENTS IN BLAST FURNACE PRACTICE.

PRACTICAL RESULTS IN THE APPLICATION OF THE DRY-AIR BLAST TO THE MANUFACTURE OF IRON.

James Gayley—Iron and Steel Institute.

NOTWITHSTANDING the advances which have been made in recent years in the manufacture of steel and its resultant products there has not, until very recently, been a corresponding progress in the method of making the raw material of the steel furnace, the pig iron which is the first stage in the treatment of the ore in the blast furnace.

At the last meeting of the Iron and Steel Institute there was presented an important paper by Mr. James Gayley, giving an account of practical results in the increase of the efficiency of the blast furnace by a method which had until then been almost neglected.

This point, to which Mr. Gayley has directed his attention, is the question of the influence of the contained moisture in the air upon the action of the furnace, a matter which appears to be well worthy of the close attention and experiment of all manufacturers of pig iron. As Mr. Gayley points out, the closest effort has been given to securing uniformity in the various elements of the charge, while all the time there has been a far greater variation in the constitution of the air forming the blast than with any other material entering the furnace.

"Great and important improvements have been made in the blast-furnace and its accessories, as in the hot-blast stoves, the increase in size and change in the shape of the furnace, more efficient blowing-engines, the increased protection given to the bosh walls, and in the careful preparation of the raw material, all of which have exerted a pronounced influence on the further operations from a metallurgical standpoint. During the past eight years but little advance has been made in this direction; the fuel consumption has not diminished, nor has there been any material increase in production. Within this period, however, there has been witnessed the greatest development in appliances for the economical handling of material, and so complete has been the work in this direction, that, except in isolated cases, in this country at least, a further extension does not hold out much promise of a satisfactory return on the investment required. It seemed that, with the exception of the gas-engine, we had about reached the limit, for like a strong wall the atmosphere, with its humidity as variable to-day as when first blown into a primitive blast-furnace, appeared to stand as a barrier to further progress. In furnaces using ore from the Lake Superior district the raw material, amounting to about 7,200 pounds per ton of iron, varies in composition within 10 per cent. and is as uniform as human skill can make it; but the atmosphere, of which 11,700 pounds are consumed per ton of iron, varies in its content of moisture from 20 to 100 per cent., from day to day and often in the same day, thus rendering the process, even with the best appliances, an uncertain one and dependent on the caprice of the atmosphere."

The deteriorating influence of moisture in the blast furnace is well understood by managers, since the leakage of water from a tuyere is known to be followed by a serious chilling effect, but few realize the quantity of moisture which is introduced with the air under ordinary atmospheric conditions. Mr. Gayley computes that the presence of one grain of water per cubic foot of air corresponds to about one gallon of water per hour for each 1,000 cubic feet used per minute, while meteorological records show that in the vicinity of Pittsburg the quantity of moisture in the air ranges from 3 to 7 grains per cubic foot, according to the season.

"By simply multiplying the grains of moisture by 40—which represents the number of gallons of water entering a modern furnace per hour, for a content of 1 grain of moisture in a cubic foot of air—a clear idea can be had of the gallons of water entering the furnace per hour, for the various conditions of humidity. The changes are great not only from day to day, but from hour to hour in the same day, and often they are very abrupt. These records were made at a furnace plant, located on the bank of a river, where the conditions exist for an increase in humidity as compared with higher ground; and to what extent the abrupt changes may have been caused by the presence of steam in the atmosphere—absorbed from spraying of the hot pig beds, the blow-off from boilers and exhaust from engines, or from a rainstorm, when the humidity decreases suddenly—it is impossible to say. How frequently has it happened in the experience of every furnace manager, that the furnace has gradually or suddenly lost its hearth temperature and produced a grade of iron either undesirable or unmarketable, without any visible cause. Tuyeres are examined for leaks, the raw material in the stockyard is carefully inspected, and usually the coke is condemned. A more intimate acquaintance with the atmosphere would have provided a correct and ready reason, for the variations therein are not only many times greater than in the raw material, but a greater weight of it is used per ton of iron."

In view of these facts it became evident that experiments with dry air might result in a material improvement in blast-furnace performance, and hence various schemes were investigated with a view of determining upon the most feasible for practical use. It was finally decided to remove the moisture from the air by means of cold, the moisture being deposited upon the coils of a refrigerating machine, leaving the air practically dry. By constructing an experimental chamber containing coils connected with an anhydrous ammonia refrigerating machine, and using steam to charge the air to any determinate degree of moisture, data were obtained for use in designing an operative plant.

This operative plant has been built for use with the Isabella furnace, near Pittsburg, and the details of the apparatus are very fully shown in the paper of Mr. Gayley. The apparatus does not differ materially from a standard refrigerating plant, using anhydrous ammonia in connection with a brine tank and circulating coils. The plant has a capacity corresponding to the melting of 225 tons of ice, for one compressor, there being a reserve machine of equal capacity. The cooling coils for the air contain 90,000 lineal feet of 2-inch pipe, so arranged as to distribute the incoming air over the whole surface, the moisture being deposited in the form of frost.

This plant has been in operation since August 11, of the current year, and it has fully demonstrated the value of the system. The ore burden for 10,200 pounds of coke has been increased from 20,000 pounds of ore to 24,000 pounds, a gain of 20 per cent., while the reduced load on the blowing engines, due to the reduced volume of the cold air, fully makes up for the power required for the compressor.

"The application of the dry-blast to the blast-furnace has shown, in addition to the economies effected, that the furnace can be operated with precision; it works with greater regularity, and in consequence the product is uniform with respect to grade and composition, which makes the dry-blast of particular value in the making of foundry iron, which is marketed by grade. An increase or decrease in blast temperature has a definite effect and can be relied on to accomplish the desired result.

"The dry-blast plant since it was started on August 11 has been in regular operation. It started without a hitch and no dif-

ficulties have developed in any direction. Some modification in construction has been indicated as the result of the operation of the plant which would further reduce the moisture and add to its uniformity, but so far the changes suggested have been slight.

"While the application of the dry-blast to the blast-furnace has effected various economies and produced a more uniform metal, its further application to the Bessemer converter would no doubt result in great benefit, since air is used in large quantities and the varying humidity affects the temperature of the charge and in consequence the quality of the steel. The metal from the metal-mixer is remarkably uniform and the additional uniformity secured through the use of dry air would be of further advantage. It happens that a higher silicon is required in he summer months to maintain the temperature of the blow, in which period it is also more expensive to maintain the right amount of silicon in the pig-iron. With the use of the dry-blast in the converter the proper temperature could be secured with a lower silicon in the metal, and this in turn would further reduce the coke consumption at the furnaces. In other processes where air is used in large quantities—particularly in smelters and copper converters and in the open-hearth furnace and in cupolas—it would appear that the use of dry-air would effect important economies.

MODERN MASONRY ARCHES.

IMPROVEMENTS IN DESIGNS AND CONSTRUCTION WITH A VIEW OF SECURING A BETTER UTILIZATION OF THE MATERIAL.

M. Séjourné—Révue Générale des Chemins de Fer.

WHILE the arch is one of the oldest forms of construction for spanning an opening it has been improved but slowly, and even to-day there is room for modifications which shall add to its stability and efficiency. This is especially the case with arches of large span, and the increasing use of masonry bridges in the place of steel structures has called attention to the room for improvement.

In a paper recently contributed to the *Révue Générale des Chemins de Fer,* by M. Séjourné, the economical construction of large masonry arch bridges is discussed, and the conditions leading to efficiency are shown.

As is well known, the dead load constitutes by far the greater portion of the weight supported by an arch of masonry, the live load forming such a small proportion as to be almost negligible for large structures. Since the carrying of the live load is the real object for which a bridge is built, it is evident that the efficient use of the material is measured by the proportion of dead to live load, and that any method of diminishing the amount of material used in an arch of given span and width will conduce to an increased efficiency.

There appears to be no way of reducing the dimensions of a given arch in a manner which will give an increased efficiency to the material under the ordinary methods of construction. The depth at the key and at the springings, and indeed the general dimensions of the arch ring cannot be controlled entirely by the considerations deduced from the computed pressures, since the position of the curve of pressure is, to a certain extent, indeterminate, and the ring must be made sufficiently deep to include the curve of pressure beyond any reasonable doubt. There are also aesthetic considerations which cannot be ignored, and when all these are taken into account the proportions of an arch of given rise, span, and loading are closely limited.

Another method of economizing material, however, has been devised and successfully executed in a recent important structure, and it is also to be employed for another large bridge of recent design. This method is the employment of two narrow arch rings, with a flat connecting flooring to carry the moving load. We have already referred to the employment of this plan in the construction of the great Luxembourg arch of 84.65 metres (277.73 feet) span, and details of this great structure are given and illustrated in the paper of M. Séjourné. In the case of the Luxembourg bridge the total clear width of the bridge is 16 metres, and

each of the arch rings is made 5.25 metres wide. There are thus two separate arches, placed side by side, and identical in every respect, with a space of 6 metres between the two arches, this being covered at the roadway level by a flooring in reinforced concrete.

This arrangement possesses several advantages. In the first place fully one-third of the masonry is dispensed with, and this includes the most expensive kind of masonry, being the cut stone voussoirs of the arch ring. In the second place it permits a single centering being used for both arches, and in the case of arches of large span the saving in large and heavy timbers is an important element in the expenditure. In the case of the Luxembourg arch a centreing was made for the single arch, and after this had been used for one ring it was shifted laterally until it was in position for the second ring, and the cost of this movement was much less than would have been necessary for the construction of a centreing for the full width of the whole bridge.

The flooring which spans the space between the two arches is readily made capable of sustaining that portion of the moving load which comes upon it, and in this respect it is not greatly different from the flooring of an ordinary truss bridge, which is sustained entirely by the spans on each side. In the case of the Luxembourg arch the total cost was 1,500,000 francs, and it is estimated that fully 500,000 francs was saved by the adoption of the double arch design.

The satisfactory result obtained at Luxembourg has doubtless influenced M. Résal to advocate the use of the same principle in the case of the new bridge to be built over the Garonne at Toulouse.

The bridge is to have five elliptical arches, of spans of 46, 42, and 38.5 metres, with a rise of about one-fourth the span in each case, and it is intended to make the arches in pairs of 3.25 metres in width, with a space of 9.5 metres between them. The width of the roadway will be 13.2 metres, and the sidewalks 4.4 metres, these latter partially overhanging the arches. By adopting this form of construction a bridge of 16 metres in width is obtained by constructing two sets of arches of 3.25 metres width each, the centreing being used twice for each arch. The result of the adoption of this plan is a saving of 300,000 francs, while the effectiveness of the whole is not diminished in the slightest.

The successful demonstration of the feasibility of this method of constructing masonry arch bridges should lead to its general adoption, especially for large spans in which the saving is proportionally greater, and there is every reason to believe that the plan originally adopted for the great Luxembourg arch will come into general use.

GAS, OIL, AND STEAM ENGINES.

THE RELATIVE ECONOMY ATTAINED BY INTERNAL-COMBUSTION AND STEAM ENGINES IN THE GENERATION OF POWER.

Michael Longridge—The Engineer.

THE question of the production of motive power from combustible materials is one which has been discussed by many able engineers, but the constantly changing phases of the problem make it always of interest and value. This is especially the case since the development of the different forms of internal-combustion motors has broadened the subject and extended it so as to include other engines than those operated by the vapor of water. In an interesting address, delivered by Mr. Michael Longridge before the British Association of Managers of Textile Works at Manchester, and published in the *Engineer*, the relative advantages of gas, oil, and steam for power generation are examined in a very clear and interesting manner, and we make some abstract of his paper.

For the purposes of comparison between the three types, Mr. Longridge takes the following rates of fuel consumption:

A steam consumption of 11.1 pounds per indicated horse-power-hour,

A gas consumption of 82.4 cubic feet per horse-power-hour, and

An oil consumption of 0.334 pounds per horse-power-hour.

These are not record figures, but represent what has been done by the three types respectively in good modern practice. They will not suffice, however, to enable the engines to be compared without additional information. It is necessary to compare them in units of the same kind. This may be done by reducing these several fuel consumptions into British thermal units, taking into account the calorific power of the gas and oil, as well as the number of heat units contained in the steam, and upon this basis the heat consumption of the three engines work out, per indicated horse-power-hour: steam engine, 13,011 B. T. U.; gas engine, 8,817 B. T. U.; and oil engine, 5,930 B. T. U. From the fact that one horse-power-hour represents 2,562 B. T. U. it is readily seen that the steam engine has an efficiency of 19.65 per cent., the gas engine, 29.1 per cent., and the oil engine the high efficiency of 41 per cent.

Mr. Longridge proceeds to show that no heat engine can be expected to return 100 per cent. of the heat supplied to it, because of the limited temperature range through which it can be operated. Instead of proving this by mathematical demonstration, he uses the excellent simile of the utilisation of a fall of water, showing that it is not the total head of water which is to be considered, but only the difference of level actually existing between the upper level and the position of the wheel. Applying this principle to the temperature differences in the several cases under consideration, it appears that the steam engine could not convert more than 38 per cent. of the heat supplied to it into work; while the highest possible efficiencies of the gas and oil engines would be 74 and 84 per cent. These latter efficiencies must be considered merely as approximations, since the maximum temperatures in the cylinders of internal-combustion engines have not yet been precisely determined.

Mr. Longridge proceeds to discuss the Carnot cycle in connection with the possible development of heat engines, showing that while the maximum theoretical efficiencies cannot be wholly realized, they may be approached more closely by the use of this cycle than by any other action. On the pressure-volume diagram the Carnot cycle is represented by four curves, two being adiabatics and two isothermals. On the temperature-entropy diagram, the Carnot cycle appears as a rectangle, the isothermals being horizontal lines, and the adiabatics, verticals.

The impossibility of realizing the Carnot cycle in a steam engine is evident when it is understood that it requires the absence of clearance and of cylinder condensation, and demands that there should be neither absorption or giving out of heat by the cylinder walls.

The nearest approach to the Carnot cycle which can be expected in a steam engine is one in which the final adiabatic compression is omitted, and from computations based upon the equations of Rankine, Mr. Longridge gives the various maximum efficiencies for saturated and for superheated steam, at several pressures, taking the superheating at the maximum practicable temperature of 800° F. At 200 pounds pressure, with saturated steam this gives a possible efficiency of 30.3 per cent., and with steam superheated 800°, an efficiency of 33.1 per cent.

"The sources of waste which interfere with the attainment of these standards are:—

"First, radiation, which may be rendered unimportant by careful covering of pipes and cylinders.

"Secondly, wire-drawing, which, unless the fall in pressure is very great, is not of serious consequence except when it occurs between the cylinder and the condenser. A certain amount of wire-drawing between the stop valve and the piston may even be beneficial, for, since no heat is lost, the drop in pressure is utilized in evaporating moisture or in superheating the steam, if it be already dry. The remedy is large passages and ports, but it must always be remembered that large ports mean large clearance spaces, and what is more detrimental still, large clearance surfaces.

"Thirdly, cylinder condensation. The cylinder metal cooled by the previous exhaust stroke absorbs heat from the incoming steam, condensing part of it during the admission and early part of the expansion, and gives out this heat again during the later part of the expansion and exhaust, thus breaking Carnot's laws that all heat must be supplied at the highest tempera-

ture, that the expansion must be adiabatic, and that all the heat must be rejected at the lowest temperature. This is a very important source of loss, especially in reciprocating engines. In turbines it is not so great, because the steam enters at one end and passes out at the other. Thus the hottest steam does not come in contact with the coldest metal. The remedies are multiplication of cylinders to reduce the range of temperature in each; steam jacketing for slow revolution engines; and superheating, if possible, to such an extent as to keep the steam dry throughout the stroke.

"Fourthly, leakage past valves and pistons. This may also be important. The remedies are—the adoption of shapes least subject to distortion by heat and pressure; accurate and highly finished workmanship, and superheating. You know the velocity of a fluid flowing through an orifice, such as must exist between a valve and its seating if there be leakage, is proportional to the square root of the pressure forcing the fluid through; consequently the weight of fluid forced through in a given time depends upon its density; therefore, as water is 500 or 600 times denser than superheated steam, the leakage will be 500 or 600 times greater when the steam is wet than when it is dried by superheating.

"Fifthly, incomplete expansion. The figures relating to the standard engine are calculated on the supposition that the expansion is continued till the pressure falls to that in the condenser. Practically, it will not pay us to expand to so low a pressure. First, because the cylinder required would be so enormous. Secondly, because a pressure less than that required to drive the engine itself is no use to us."

Mr. Longridge shows also that the attainment of the Carnot cycle is impossible with the gas engine.

"The isothermal combustion of the gas, the expansion without loss of heat, the sequence of isothermal and adiabatic compression, alone present insuperable difficulties, and gas engine makers have not made the attempt to overcome them. They have chosen an entirely different mode of action. Gas and air mixed together and compressed into the clearance space are fired by a gas flame or electric spark; the combustion is accompanied by a rapid rise of temperature and pressure; the heated gases expand, driving the piston forward; at the end of the stroke they escape into the air; a fresh charge of air and gas is drawn in, compressed into the clearance space, and fired. In some cases the cycle is completed in four strokes, in others in two. In all engines the cylinders, and in large engines the pistons and the piston-rods, if there are any, are cooled by water, which carries off large quantities of heat."

According to computations by Mr. Dugald Clerk, the maximum efficiency attainable by the gas engine is about 45 per cent., and in practice only about 57 per cent. of this is actually attained, owing to unavoidable losses with the exhaust and in the cooling water.

In the case of the oil engine, the only attempt to approach the Carnot cycle is made in the Diesel motor, and theoretically this offers a very close approach to the most efficient cycle.

"The ideal Diesel engine is a very near approach to Carnot's perfect heat engine. Its characteristics are:—

"(1) Production of the highest temperature of the cycle, not by or during combustion, but before and independently of it, solely by compression of air.

"(2) Gradual introduction of the combustible into the compressed and heated air during the first part of the stroke in such a way that the heat produced just keeps pace with the work done by the piston, so that the combustion is isothermal.

"(3) The use of charge of air proportional to the heating value of the combustible, and sufficient to keep the cylinder temperatures within such limits that the working of the engine and its lubrication may be carried on without any water jackets. Its thermal efficiency is almost the same as that of Carnot's perfect heat engine.

"Practically, this ideal has not yet been realised, but it is so high that even the distant approach to it which has been made is in advance of the economy of any other engine.

"The actual cycle adopted as a compromise between theoretical and practical requirements is:—

"(1) Outward stroke; Admission of air at atmospheric pressure.

"(2) Inward stroke: Compression of air to about 500 lb. per square inch and 1,000° F.

"(3) Outward stroke: gradual admission and combustion of oil, followed by expansion.

"(4) Inward stroke: Expulsion of waste gases.

"The indicator diagrams are similar in appearance to those taken from a non-condensing steam engine working with a high pressure, early cut-off, and high compression."

Theoretically, the Diesel motor as constructed, should give a maximum efficiency of 67 per cent., and tests show that about 63 per cent. of this is actually attained.

Although most conservative in his conclusions, Mr. Longridge does not hesitate to say that he believes that before long the more economical forms of internal-combustion engines will become formidable rivals to the steam engine for factory driving, and may ultimately supplant it.

ARTIFICIAL VENTILATION ON SHIPBOARD.

EXPERIMENTAL INVESTIGATIONS WITH VENTILATING FANS ON VESSELS OF THE UNITED STATES NAVY.

Naval Constructor D. W. Taylor, U. S. N.—Engineering News.

AMONG the problems involved in the equipment of a modern ship of war must be included that of adequate ventilation. On the great passenger liners this is naturally an important matter, but it also demands consideration on a battleship or cruiser, especially since these latter are often sent for duty in the tropics, and in any case must be the residences of their occupants for comparatively long periods of time.

Some of the recent experiments which have been made in vessels of the United States Navy are discussed in a paper by Naval Constructor D. W. Taylor, published in a recent issue of *Engineering News*, and some review of the principal points is given.

Rotary fans attached to pipe systems for forced or mechanical ventilation were first fitted on United States vessels by Ericsson on his monitors. They have figured more or less on our naval vessels ever since, even upon the wooden vessels built in the seventies. Until about seven years ago steam fans were used. The earliest vessel to have a complete outfit of electric fans was the "Nashville," first commissioned in 1897. For five years or more all ventilating fans have been electrically driven. In the earlier vessels of the new Navy, built between 1885 and 1890, it was customary to fit a few large steam fans for ventilating living spaces, and these were so fitted with a system of flap valves that they could be used either as supply or exhaust fans. When such a system, after being run exhausting for some time, was changed to supply air, it blew into the living spaces an astonishing amount of dust which had accumulated in the pipes. At present, while both supply and exhaust systems are fitted, the tendency is to rely mainly on the former and use the latter only for such places as lavatories, water closets, dynamo rooms, steering engine rooms, etc. Probably under conditions on shipboard a supply system requires less power to move a given quantity of air. A distinct advantage is that with single piping fresh air is supplied positively. With an exhaust system the air which takes the place of that exhausted is not necessarily fresh, unless supply pipes are fitted as well as exhaust. The principal practical objection to a supply system of ventilation is that in cold weather it is very difficult to avoid unpleasant draughts from it, and it is apt to be shut off. In the tropics, however, where ventilation is most needed, the cooling currents from a supply system are found grateful and pleasant.

At present, using electric power, a great many more fans are fitted than was customary when steam was used. There are advantages in using a number of separate fans. The piping is simpler and fewer holes in watertight decks and bulkheads are required. But with steam power the use of a number of small fans would involve a network of steam and exhaust pipes which could not be considered for a moment.

Mr. Taylor describes especially the experiments which have been made on the battleship Missouri, this being a typical ex-

ample of the ventilating plants on the later battleships, and the extent of this department will be realized when it is understood that on this vessel there are 32 fans, requiring motors aggregating 87 horse power for their operation.

The solution of the problem of supplying a compartment or number of compartments on a ship with fresh air requires the solution of two interdependent problems, which may be stated as below:

(1) Given a properly designed system of piping and outlets, with what maintained pressure at the fan outlet will this system deliver the required quantity of air?

(2) What fan will deliver at its outlet the required quantity of air and maintain the required pressure with the minimum expenditure of power?

The experiments made have dealt mainly with the second problem. It was determined in the beginning to obtain results from the fans when working under conditions practically the same as when in service on board ship. This required that each fan should discharge against pressure into a pipe somewhere near the size of its outlet and that the pressure in the pipe and velocity of the air should be determined simultaneously with the actual power being delivered to the fan.

Mr. Taylor describes in detail the tests made upon selected fans operated by special electric motors through a spring torsion dynamometer, the air velocities and pressures being measured with a special form of Pitot tube. A number of such tests were made at the Model Basin at the Washington Navy Yard, and from the results thus obtained the corresponding characteristic curves for several fans were plotted. From the formulas deduced from the laws of similitude these results may be applied to similar fans of other dimensions and speeds. The value of these experiments, therefore, extends beyond their immediate application, and they form an acceptable contribution to an important department of applied science.

Among the experiments may be noted also those to determine the pressure required in a pipe to maintain a certain discharge. This involves the determination of the friction of air in plain cylindrical pipes. The method employed was that of measuring the velocity and pressure of air at two different points on the same pipe, the points being separated by a distance sufficiently great to enable reliable quantitative results to be secured.

The following conclusions were deduced from the experiments:

(1) The coefficient of friction does not change with the velocity of the air for velocities up to 6,000 ft. per minute.

(2) The coefficient of friction does not change with size of pipe, at least up to sizes three or four square feet in sectional area.

(3) The friction varies at the squares of the velocity of air through the pipe.

(4) The coefficient of friction for pipes of the best workmanship in the best condition is as low as .00008.

The paper of Mr. Taylor forms a most useful contribution to this important department of work, and it will be found of service not only for marine work, but also in connection with stationary installations.

INTERNAL TRANSPORT IN THE UNITED STATES.

THE DEVELOPMENT OF MERCHANDISE TRAFFIC ON IMPROVED WATERWAYS AND RAILROADS IN AMERICA.

E. P. North—American Society of Civil Engineers.

AMONG the valuable papers presented at the Engineering Congress held by the American Society of Civil Engineers at St. Louis we note one by Mr. E. P. North, treating of the development of internal transportation of merchandise in the United States, from which some extracts are given.

"In one great source of national wealth, cost of transportation, which is not a natural product, the United States has an unisputed advantage over all other countries. Shortly before his death, Mulhall said that the average rate received by railroads of different countries for transporting a ton of freight one mile was, reduced to cents: United Kingdom, 2.80; Italy, 2.50; Russia, 2.40; France, 2.20; Germany, 1.64; Belgium,

1.60; Holland, 1.56; United States, 0.8. These figures show that the low cost of internal transportation has been the principal cause of its augmented wealth; an augmentation that was greater in the decade ending with 1900 than during the 80 years preceding 1870. For not only does a low freight rate allow more to be divided between producer and consumer, but it has a more potent effect in inviting the production of commodities which with higher freight charges could not reach consumers; thus adding greatly to the employment offered to labor and capital."

Comparing the tabulated result from Poor's Manual, Mr. North showed that the ton-miles per annum increased 2.5 times from 1885 to 1902, while the earnings nearly doubled, and the maximum freight rate fell from 1.057 cents to 0.764 cent.

"If the rates had remained as in 1885 there would have been paid $3,500,000,000 more for transporting our freight than was the case, and if American freight rates had been equal to those of England, as stated by Mulhall, and with as large a volume of business possible at such rates, the cost would have been nearly $33,000,000,000 greater, or more than the increase in wealth during the last decade. American railroad freight rates are the lowest in the world, and this is probably true also of coastwise freight rates. The low cost of assembling and distributing commodities has also had an important influence on their production and consumption.

"It is noticeable that this distinctive position as transporters has been reached with the highest wages paid for labor known and until lately with a higher cost for materials than those of neighbors and competitors. But both the high wages and high prices have, by stimulating production and consumption, added to the volume of freight moved and reduced its cost."

Mr. North examines in detail the conditions surrounding the growth, both of railways and waterways in the United States, showing the impetus which has been given by State, Government, and local aid; and until recently there has been freedom from those laws which are based on the theory of vested interests. Indeed the menace to invested capital is a doctrine hardly 25 years old in the United States.

"The British Government in 1853 subsidized its main lines of steamers 'to afford a rapid, frequent and punctual communication with those distant ports which feed the main arteries of British commerce, etc.'; refusing aid to, if not oppressing, internal communication. On the other hand, the Government of the United States, and also individual States, counties and localities, subsidized the turnpikes, watercourses and railroads almost entirely for the improvement of internal communications, and neglected or oppressed our efforts to reach distant ports. England is pre-eminent as a ship-building and ship-sailing country, but its people pay the highest internal freight rates known. America now has a contemptible merchant marine, but its internal freight is handled at a rate unapproached in other countries. If, as has been lately urged, the United States Government was unable to develop at one time both foreign and internal communications, it has apparently adopted the most profitable alternative, although its annual payments to foreigners for over-sea freights are said to exceed the receipts from either custom dues or the internal revenue tax."

The traffic on the Great Lakes forms an important element in the internal commerce of the United States, and a measure of the magnitude of this water transport may be found in the records of the tonnage passing through the Sault Sainte Marie canal, popularly called the "Soo." Thus the tonnage of the canal in 1881 was 1,568,000, and this rose to 8,889,000 tons in 1891, and to 36,674,437 tons in 1903!

"As only 41½ of the 958¼ miles between Duluth and Buffalo have required improvement to accommodate vessels of 20-ft. draft, and the same improvement has sufficed for the 885 miles between Chicago and Buffalo, the combined traffic on these routes being without an equal in any other channel, no other improvement undertaken by the Government has had so beneficent an effect on our national wealth, nor has returned so large a dividend on the money expended."

Summing up, Mr. North shows the great influence which has been exerted by the development of means of internal transport upon the growth of the entire country.

"The United States possesses no noticeable superiority in natural resources, and

is handicapped by the necessity of finding money to do in a part of a century that for which other countries have taken nearly a thousand years. It has in the aggregate exhibited a superiority in general honesty of purpose and in the broad-mindedness of its legislators, both national and local. It is largely through legislation, notably and peculiarly in its help to all schemes for increasing wealth by diminishing the cost of interchange between producers and consumers, that the United States has attained its superiority. From the fairly equal distribution of subsidies and direct payments between waterways and railroads, there has issued a system of mutually beneficent rivalry, in that the railroads often own boat lines and the boat lines have owned railroads, which has given a higher remuneration to the producer, and a lower cost to the consumer, than would have been possible under any other system.

"As a result the internal commerce for 1902 is estimated at $20,000,000,000. This estimate is based on one transaction in each of the leading classes of commodities produced in the several different divisions of national industry. The foreign commerce amounts to nearly 12 per cent. of this sum, and 6.8 per cent. of it suffices to settle foreign balances, and pay for foreign transportation with such luxuries and raw materials as are required from other countries.

"Exclusive of the benefits derived from land grants, there seems to be no reason why any other country should not develop its transportation systems in a manner analogous to that pursued by the United States and reap as substantial a reward."

THE SPEED OF STEAM VESSELS.

THE RELATIONS OF POWER, FUEL ECONOMY AND ENDURANCE OF STEAM-PROPELLED VESSELS AT VARIOUS SPEEDS.

Commander J. F. Ruthven—Royal United Service Institution.

IN view of the important part which sea power is playing in the affairs of nations, as well as the bearing which marine efficiency has to commercial supremacy, the questions of the relations of power, speed, and fuel consumption of vessels are most important. These are discussed in an eminently practical way in a paper by Commander J. F. Ruthven, published in a recent issue of the *Journal of the Royal United Service Institution.*

"The amount of fuel required by a modern steamship, whether for the purposes of warfare or commerce, is a most important factor in estimating her usefulness and efficiency. In designing a battleship or cruiser, a torpedo boat or destroyer, as well as in the case of a mail or cargo steamer, the naval architect has, in conjunction with the engineer, to take into account the coal capacity and endurance that will, whilst fitting in with the general design, give the best results, and it behoves those who have to handle the floating mass of mechanism that constitutes a modern war vessel, or greyhound, to understand the effects of varying the speed, so as to get the best value out of the coal on board according to the object in view. In every case it is necessary to ensure its lasting to the next port, and in time of war it would certainly be desirable to have a sufficient reserve to be able to steam at extreme speed towards the end of the voyage, either for the purpose of chasing or avoiding a chaser, which might only be made possible by husbanding resources at an easier speed in the earlier stages of the passage. A modern man-of-war with her bunkers burnt out would lie helpless under the stroke of perhaps a much smaller antagonist that could choose her own time and method of attack, besides being exposed, in common with all other steam vessels in similar circumstances, to such possible dangers as a lee shore, etc.

"The capability of greater speed at a critical moment means increase of power in more senses than one. Not only does it mean more horse-power in the cylinders, but perhaps more power in using weapons that is equivalent to greater power in the weapons themselves, or, what is practically the same thing, a diminution of the offensive power of the enemy.

"The difference between the coal endur-

ance of two cruisers may often just mean the difference in the measure of their suitability for a particular purpose, where, amongst other conditions, steaming over a long distance is entailed. This difference may conceivably arise in the same vessel under two different commanders, only one of whom looks well ahead and thinks out, in consultation with his engineer, the details of the task set him, bringing all the scientific knowledge available, as well as practical experience, to bear on it, and providing, as far as human foresight can, for every possible contingency that may arise."

Commander Ruthven accepts as generally applicable, the well-known Admiralty formula, in which the power is computed as depending on the cube of the speed and the two-thirds power of the displacement, stating that he has put it to practical test during many years of almost continuous sea service, and hence is disposed to use it until it is displaced by something admittedly better.

"The speed and consumption of a steam vessel are closely related, and whilst an accurate record of the former has always been one of the special cares of the navigator, the almost universal adoption of steam propulsion has not given him another measure of the velocity of his vessel, but has forced him to consider this in relation to the amount of fuel he has on board, to make sure that it will enable him to reach port.

"If the water did not yield to the thrust of the screw propeller, the ship would be forced ahead for each revolution as many feet as correspond to its pitch, and we should thus have an accurate measure of the speed—more accurate than any log.

"Owing to the resistance of the ship, and the water yielding to the propeller, the distance moved by the ship is usually less than that due to the revolutions and the pitch, and the difference is the *apparent* slip, or, as it is generally called shortly, the slip. It is commonly expressed as a percentage of the distance run by the propeller. The slip varies in different vessels and even in the same vessel under different circumstances, especially if there has been any alteration in the propeller. Once it has been correctly ascertained for any ship where the propeller, or propellers, are kept constantly immersed, the revolutions of the engines give, in moderate weather, the most accurate and trustworthy record of speed through the water, and it is a simple operation to make out a table of speeds corresponding to revolutions with various percentages of slip. The amount of slip to allow in each case can only be arrived at by experiment or experience, and is generally determined during the builder's trials. It rises slightly with increased speed or displacement."

Having thus at hand a convenient and reliable measure of speed, it is only necessary to keep a record of fuel consumptions at standard speeds and displacements to be able to compute the fuel consumption for any other conditions.

Here an important point enters. A considerable portion of the fuel burned under the boilers goes to generate steam to supply the auxiliaries, such as pumps, electric-light engines, refrigerating machinery, ventilators, etc. The amount of steam consumed by these does not vary with the speeds, but is nearly constant at all speeds, and hence it is important to estimate the consumption for the main engines separately from the auxiliaries. The consumption due to the main engines varies about as the cube of the speed, while the consumption of the auxiliaries is practically constant.

Thus, when a commander of a steamer finds his coal margin running low, he can readily compute the saving he can make by reducing speed, the fuel required for the main engines diminishing in proportion to the cubes of the two speeds. Thus if the speed be reduced one-half, the coal consumption will be but one-eighth, and a reduction in speed from 20 knots to 16 knots will cut the coal consumption in two. But the fuel consumption for the auxiliaries, being the same at all speeds, may fairly be measured by time, and hence it will be increased as the voyage is made longer, and the loss from this cause must be deducted from the gain realized by slowing down the main engines.

Under these circumstances the importance of improving the performance of the auxiliary machinery on shipboard will be realized, and indeed, since the paper of Mr. White, on the auxiliaries of the Minneapolis, reviewed in these columns in May,

1898, there has been increasing attention given to this matter. Thus, many engines and pumps formerly run simple, and with little or no expansion, are now made compound, while much care is given to the prevention of wasteful leaks. In many instances small engines used for operating fans and other light machinery have been replaced by electric motors, deriving current from a generating set of good efficiency, and dispensing with much piping and condensation losses. The exhaust from the auxiliaries is also used in feed water heaters and other economizing devices, and in some cases the excellent plan is adopted of arranging all the auxiliaries to exhaust into the receiver of the main engines, to the material improvement in fuel consumption.

Commander Ruthven's paper is an excellent example of the importance of looking at engineering questions from a practical, as well as a scientific point, and it forms a useful contribution to the study of current engineering problems.

THE GAS TURBINE.

A SCIENTIFIC INVESTIGATION INTO THE POSSIBILITY OF APPLYING THE TURBINE PRINCIPLE TO THE DIRECT USE OF THE GASES OF COMBUSTION.

R. M. Neilson—Institution of Mechanical Engineers.

WE have already referred in these columns to the experiments and theoretical studies which have been made upon the Continent as to the use of the gas turbine, and now we have a very suggestive paper presented before the Institution of Mechanical Engineers giving a further discussion of the important matter. Mr. Neilson writes wholly from the academic viewpoint, having made no experiments upon actual machines, and indeed, with the exception of the turbine of MM. Armengaud and Lemale, to which reference was made in our last issue, there appears to be no definite information available about any operative or operating gas turbine whatever.

Starting with the well known formula, due to Carnot, of the efficiency of an ideal heat engine, Mr. Neilson calls attention to the point that we should strive not so much to get the maximum and minimum temperatures respectively as high and as low as possible, but to get the mean temperature at which heat is given to the gas and the mean temperature at which heat is withdrawn from it respectively as high and as low as possible, the lower temperature being by far the most important.

Mr. Neilson discusses four cycles upon which good results appear possible, and shows how these may be applied to a turbine. The first of these is practically what is known as the Brayton cycle operating with combustion at constant pressure.

"It has been proposed for gas turbines to cause air and fuel to unite in a nozzle which thereafter diverges, with the idea that the air and fuel will combine on meeting each other, and the hot products of combustion then acquire a high velocity in the divergent nozzle, with which velocity they will enter the turbine buckets. The results of a trial of such a scheme would be interesting. The author doubts if the combustion would be quick enough to give a good efficiency. If, however, a combustion chamber of ample size were provided in which the burning gases could rest a short interval before passing to the turbine, better results could, in the author's opinion, be expected. The air and fuel would be separately pumped into the chamber, from which the products of combustion would flow continuously and uniformly by one or more passages into the turbine.

"At any rate, the difficulties should not be as great with turbines working on this cycle as with reciprocating engines, as the latter have to receive the hot gases intermittently, while the turbine receives a continuous flow. This is an important point as regards controlling the flame. With an engine of the Brayton type the fuel has to be ignited in the cylinder for every working stroke, and the supply of gas to the flame has to be cut for every working stroke. With a turbine the fuel and air could be supplied at a constant velocity to the flame and a steady flame maintained without interruptions. This is important,

because, if a mixture of air and fuel be always supplied to the flame with a velocity greater than the velocity of propagation of the flame, there can, of course, be no firing back, and this result can be obtained without the use of a wire gauze screen. The maintaining of this velocity of supply to the flame above the required minimum when starting and stopping the motor and when running at low powers is, of course, a problem to be considered. The strength of the mixture of air and fuel should be kept constant. The power of the turbine can be varied by other means. It must be noted that if the air and fuel are compressed adiabatically to a sufficient extent, which depends on the nature of the fuel, combustion will occur immediately the two are brought into contact with each other. It is therefore necessary in such cases to keep the air and fuel apart until the instant when combustion is desired. It must also be noted that with a turbine there will be no hot waste gases mixed with the fresh air and gas to be compressed."

With this cycle a good efficiency should be attained with a moderate maximum temperature. If the temperatures are excessively high some form of water-cooling must be used, with the resultant loss of a great amount of heat. In such a machine there must also be some form of air compressor employed, and although the work required to effect the compression is returned to the turbine there is necessarily a loss due to the imperfect efficiency of the compressor, and this may be unduly great.

"Instead of employing cooling arrangements for the metal, some or all of the available heat energy of the gas can be converted into kinetic energy before causing it to act on the turbine, so that the latter is not exposed to an unduly high temperature. This can be done by allowing the gas when at the maximum temperature to expand in a divergent nozzle till its temperature falls to a degree that the turbine can stand. More than one nozzle can be employed, but, to reduce the radiation losses, the nozzles should be large and few in number.

"Suppose that the gas is compressed adiabatically to 300 lb. absolute and then is heated at constant pressure to a temperature of 2273 deg. abs. Cent. If now the gas be allowed to expand in a suitable nozzle adiabatic expansion can be obtained; and if this be continued till the pressure falls to 15 lbs. absolute the temperature will be 966 absolute Cent. (693 deg. Cent.). This is just below the temperature which was fixed on as a maximum for a turbine without artificial cooling.

"It may be advantageous to mention for the sake of comparison the velocities of the steam jets employed in De Laval steam turbines. If saturated steam at 50 lb. absolute pressure is expanded adiabatically to a pressure of 0.6 lb. absolute, which corresponds to a temperature of 85 deg. Fah., and its heat energy turned into kinetic energy, the velocity acquired works out at 3690 ft. per second. If saturated steam at 300 lb. abs. pressure were treated similarly, the velocity would be 4380 ft. per second. The velocities actually obtained in practice must be somewhat less than these figures owing to friction in the nozzles.

"To get the best results from a fluid velocity such as 5290 ft. per second would require with a single turbine wheel a vane speed which cannot be obtained at present for want of a sufficiently strong and light material—the stresses produced by centrifugal force are too great. This difficulty is experienced with De Laval turbines. The obvious way out of the difficulty is to employ several wheels in series, the gas passing through the several wheels with diminishing velocity, but with nearly constant pressure."

In the second cycle considered by Mr. Neilson is practically the same as exists with the present explosion engines, giving intermittent impulses, and delivering the fluid to the wheel at varying pressure. These difficulties may be overcome by mechanical devices, but some of the advantages of simplicity are then lost.

"With high-speed turbines there is another question to be considered. It has been stated that the velocity of the gases escaping from the divergent nozzles would be over 4000 ft. per second, if the heat energy converted into kinetic energy was as mentioned. The author is not, however, aware of any results of experiments having been published in which velocities of these amounts were obtained, when the pressure of the medium into which the divergent

nozzle discharged was atmospheric. It is supposed by some that there is a maximum limit to the velocity of a gas leaving a divergent nozzle and escaping into a given medium which is at a given pressure, etc., and that this limiting velocity is dependent on the pressure in the medium into which the nozzle discharges, and is less when the pressure in this medium is greater and *vice versa*. That is to say, it is supposed by some that, after a certain velocity of discharge has been attained, no increase in the initial temperature or pressure will increase this velocity; but a reduction of the pressure the medium may increase this velocity. The author does not express any opinion himself on this point, but if it should be found that the reduction of the pressure inside a turbine casing below atmospheric pressure enables us to convert the heat energy of our gas into kinetic energy more effectively, this will be a further argument in favor of so reducing the pressure. Whether or not there is an advantage to be gained remains to be proved, but there is, at any rate, a possibility of gain by thus extending the expansion, and a possibility which, in the author's opinion, should not be ignored."

The third cycle proposed by Mr. Neilson includes the utilisation of the heat of the jacket water to generate steam to be mingled with the products of combustion, and delivered with them upon the wheel, this being the method used with the Armengaud and Lemale turbine. The fourth cycle includes the use of a regenerator, and offers a very high theoretical efficiency, but offset by correspondingly high practical losses.

"To produce a gas turbine cheaply it would seem necessary to entirely avoid reciprocating parts, and to be content with a low compression.

"In many cases the vibration of a reciprocating engine is extremely objectionable; and a motor that ran with practically no vibration would be popular even if its initial cost was greater, and it was more extravagant of fuel. In motor cars, for example, oil or spirit explosion engines are used for their lightness and compactness, but the vibration they cause is objectionable. If a satisfactory turbine were obtainable, there is no doubt that motor-car builders would eagerly buy it and install it on their motor cars, even if the cost was greater and the efficiency less than many arrangements of explosion reciprocating engines now in use.

THE POINT OF VIEW.

ADVICE TO ENGINEERING STUDENTS UPON ENTERING THE PRACTICAL WORK OF ACTIVE LIFE.

Walter C. Kerr—Stevens Institute of Technology.

IN an address recently delivered to a graduating class at the Stevens Institute of Technology, Mr. Walter C. Kerr gave some excellent practical hints to the young men before him, and his words will well bear reprinting and reviewing for the benefit of engineers in all stages of their professional careers. Under the general title of the "point of view," Mr. Kerr emphasises some of the lines along which the imparting and the utilisation of a technical education may be regarded. Comparing the liberal and the technical departments of education Mr. Kerr says:—

"The so-called liberal education has always been highly academic. Trade-school engineering has been strictly non-academic. The two have joined hands fortuitously in our modern institutions. The liberal education has become less and the technical more academic, with advantage to both.

"A review of knowledge shows the great preponderance of the intellectual over the material, and it is only within late centuries, in fact almost the past century, that the human mind has seemed capable of turning from the lesser resistance of intellectual attainment to the greater capacity for physical observation and comprehension. We have but recently come to the era of intense mental operations, dealing with laws and principles which require insight greater than the intellect can grasp unless aided by the senses. Contrary, therefore, to common belief, I assert that the highest refinement of knowledge follows from the

highest use of the senses; and that it has taken thousands of years of pure intellectual development to attain a state in which the powers of nature can, through the human intellect, be made useful to mankind, and add largely to knowledge."

An important feature in the true progress of technical education is the importance of keeping the profession in close practical touch with the engineering world. This means that the professor should be given the opportunity of doing a reasonable amount of practical work for commercial purposes. This may be done during a portion of his time in connection with teaching, or, as Mr. Kerr suggests, they may go periodically into the world a few years at a time, for practice. In regard to this latter suggestion, we are impelled to say that in many instances we doubt if they would feel inclined periodically to come back, but this query can be answered only by experience. Coming more directly to the student who has acquired his technical training, Mr. Kerr gives him some good advice.

"We hear much about opportunities. They are everywhere plentiful. Remember that your opportunity is the little one that lies squarely in front of you, not the large one which you hope to find further along. Many a man is surrounded with opportunities who never seizes one. There are traditions that Adam, William Tell, and Sir Isaac Newton each had an affair with an apple, but with different results.

"Your first duty is always to that which lies across your path. The only step which you can take in advance is the next one. This leads to a simplicity of action which is commendable. Don't ramble.

"Cultivate singleness of purpose. This is more important than you may think. It is intuitive with the comparatively ignorant, and often absent in the highly trained. We are frequently surprised at the great competency of the ignorant contractor or foreman, on whom judgment is often passed by saying that he is a practical man and gets results. Analysis will show that his best quality is singleness of purpose, which leads him to do vigorously the one thing before him, without distraction following from thinking about too many other things.

"Remember that all the good you accomplish is going to come out of yourself. You cannot borrow it and you cannot make it out of that which has been poured into you by education or otherwise. All that you receive is only a certain quantity of knowledge, acquired by education, experience, or other training, which will have a certain influence upon what comes out of yourself as your own. It is the inherent capacity to perform with your own brain which will make you what you become, and not the mere transmission of that which you have acquired. Your knowledge, therefore, is of little avail until you make it inherently a part of yourself through mental assimilation and utilisation. The clearer you comprehend these things, the more readily you can make use of them as against the process of mere acquirement with a vague motive that in some way or other what you acquire may be of benefit, or that environment will be the force that makes your talent effective. Some have gone through experience without acquiring it, and many a man who has received an education has not got any because he allowed it to be a thing apart from his personality and it slipped away."

MODERN METHODS OF TESTING MATERIALS.

DETERMINATIONS OF HARDNESS, BRITTLENESS, AND ELASTIC LIMIT BY PRACTICAL AND USEFUL METHODS.

Société d'Encouragement pour l'Industrie Nationale.

AN appendix to the valuable Bulletin of the French society for the encouragement of national industry is entitled the *Revue de Métallurgie*, and this often contains most valuable papers relating to this department of the work of the engineer. Among these we note in a recent issue an article by M. Guillery, discussing some of the modern methods of determining the resistance of materials of construction, and of their applications to practical work.

Formerly the tension test was considered of the first importance, and its great value is undoubted, although the usefulness of the

information to be obtained directly from a mere statement of the ultimate resistance of a material in tension is a matter which is open to question. At the present time it is realized that the practical information desired is that of the behaviour of the material under conditions more nearly approaching those under which it is actually employed, and that its elastic limit, its resistance to pressure and to shock are the things which the constructor really desires to know.

At the new workshops at Denain, operated by the Company which has succeeded to the business of the old and well-known firm of Cail et Cie. the installation of practical shop methods of testing has been entrusted to M. H. Le Chatelier, and it is an account of these methods which is contained in the paper of M. Guillery.

Leaving aside for the moment the methods admittedly suitable for the research laboratory, M. Guillery discusses the conditions and requirements for satisfactory methods of shop testing. Broadly, the methods used should give precise indications of the quality of the metal, without leaving anything to the judgment of the operator, and these indications should be obtainable at low cost, in little time.

M. Guillery believes that the most important tests for the shops are those of hardness, or resistance, and brittleness, or resistance to impact or blows. Taking the Brinell system of determining hardness by the impression made by a steel ball he has employed simple devices for enabling this test to be made in a manner which shall enable strictly comparable results to be obtained by comparatively unskilled persons. Two forms of apparatus are described, one portable, and capable of being applied to any portion of a machine or structure, the other fixed for general shop use. In both the pressure upon the ball is determined by a number of disc springs, of the Belleville type, these being enclosed in a cylindrical case with a socket for the steel ball at one end. In the fixed apparatus the pressure is exerted by an arrangement of lever and cams, and when the movement is limited by a stop the springs have been compressed a determinate amount so that the pressure exerted upon the ball is always the same. It is only necessary to polish a small area of surface of the material to be tested, and press the ball upon it in the apparatus, and the diameter of the indentation gives a measure of the hardness and resistance. The tensile resistance is also determined by this test, since it has been shown by experiment that a direct relation exists between the impression made by the ball and the tensile strength of the material. Such an instrument is best calibrated by experiment, and it has been found that an excellent material for calibration tests is the standard bronze used for subsidiary coinage, this being readily obtained and of very uniform composition and strength.

M. Le Chatelier has devised a simple form of diagonal scale engraved on glass, which enables the diameter of the impression of the steel ball to be measured to the tenth of a millimetre by the unaided vision.

The portable apparatus is identical in construction and operation with the stationary machine with the exception that the pressure is exerted by a blow, this being taken up by the springs and converted into a determinate pressure upon the steel ball.

The great advantage of this device lies in the fact that reliable tests may be made upon the actual materials and parts composing the machine or structure under consideration, and that it does not require a separate test piece to be used. In this way all uncertainty as to the manner in which the test piece represents the material in the completed article is removed, and a far greater degree of satisfaction secured. It is possible to test portions of a structure already completed and enable comparative results to be obtained from the different parts of the same piece of work.

The impact tests made by M. Guillery are based upon the principle of breaking a nicked bar, following the practice of Barba, Fremont, Charpy, and other authorities. For making these tests, however, he employs a very simple and convenient machine, employing rotary motion, instead of the falling ram used by Fremont and others.

The apparatus consists of a sort of small fly wheel, with heavy rim, and crank and gearing device by means of which it may be rotated at a speed of about 300 revolutions per minute. A projection on the face of the wheel is arranged so that it will strike the test bar at the proper place when

the latter is pushed towards it; this being done when the wheel has attained the proper speed. A speed indicator shows the velocity of the wheel at any moment, and the loss of speed following the breaking of the bar is an accurate measure of the work absorbed in overcoming the resistance offered. The machine is arranged so that the frictional losses are reduced to a minimum, and since it has been found that correct results are obtained by the use of small bars, or *barrettes*, as they have been termed, the whole apparatus is of moderate dimensions.

By the use of such devices as are described in the paper of M. Guillery it has been found possible to maintain a close control over the quality of the materials used in the large works at Denain, and there appears to be no good reason why such simple appliances should not find useful application in many places. There is no doubt that testing would be much more frequently performed if it could be more readily done, and if the general character of a material could be ascertained within reasonable limits of error directly in the course of its passage through the shop the reliability of the products should be vastly increased.

It is not to be assumed that the use of such methods as are described in the paper of M. Guillery are intended to supersede the employment of accurate and precise testing machines in the mechanical laboratory. The fact that the work has been under the supervision of such a high scientific authority as M. Le Chatelier is sufficient indication that the limitations of the methods have been fully understood and appreciated.

TERNARY ALLOY STEELS.

PROPERTIES, CLASSIFICATION, AND UTILISATION OF SPECIAL STEELS CONTAINING CARBON AND AN ALLOYING METAL.

Leon Guillet—Société des Ingénieurs Civils de France.

FORMERLY steel was the name given to certain combinations of iron and carbon, but of late it has become evident that carbon is but one of the elements which may be combined with iron to form a steel, and indeed engineers have begun to use the somewhat indefinite term "carbon" steel to mean a steel which contains only carbon and iron, in distinction from those which are made with other constituents.

The properties of the so-called "alloy" steels have been given careful study by the French metallurgist, M. Leon Guillet, and various papers upon the subject have appeared by him in the technical press, some of these having already been noticed in these columns. In a paper recently contributed by him to the *Mémoires* of the Société des Ingénieurs Civils de France, the special ternary steels are given a systematic study in a very complete and useful manner.

By a "ternary" steel M. Guillet explains that he means a steel containing iron, carbon and one other metal, this last being intentionally added to produce definite qualities in the product. The steels considered in the paper include those to which have been added in various proportions the metals nickel, manganese, chromium, tungsten, molybdenum, vanadium, silicon, titanium, aluminum, cobalt, and tin.

The paper is divided into sections treating of each of these alloys, and the various sections discuss the preparation, properties, and applications of the products. In such an exhaustive treatment of a most important subject it is impracticable for us to do more than call attention to the most important points brought out, leaving the engineer to examine the original memoir, as a most valuable contribution to the materials of engineering.

In studying the different alloy steels M. Guillet has made use of the methods of metallography, or microscopic photography, as well as those of mechanical testing. The latter work included tension tests upon machines provided with automatic recorders, drop tests according to the method of Fremont, using nicked bars, and hardness tests by the method of Brinell, based on the impression made by a steel ball. The elastic limit was determined in some cases from the diagram made by the testing machine, and in others by the method of Fremont, observing the moment at which the polished surface of the test piece lost its brilliancy.

M. Guillet treats first of the nickel steels, dividing these into three classes, pearlitic, martensitic, and polyhedric, according to their micrographic appearance. The pearlitic steels, containing about 0.12 carbon and 2 per cent. of nickel, are very homogeneous, offering a high resistance to shocks, and being well adapted to surface hardening by cementation. Among the higher alloys mention is made of the 36 per cent. nickel alloy, known as invar, because of its freedom from appreciable expansion or contraction by heat, and of the 48 to 50 per cent. alloy, called platinite because it possesses the same coefficient of expansion as platinum or glass, and hence may be used as a substitute for platinum wire in fusing into glass.

Manganese steels, originated in 1888 by Hadfield, are prepared by the addition of ferro-manganese, this alloy, as made in the blast furnace, containing as high as 80 per cent. of manganese and 7 per cent. of carbon. A very pure ferro-manganese is prepared in the electric furnace, or by the Goldschmidt process of aluminothermy. The manganese steels used in practice contain about 5 per cent. of manganese and 0.80 carbon, and by reason of their combined hardness and toughness find numerous useful applications, such as the construction of jaws for crushers, grinding rolls, etc. M. Guillet believes that manganese steels are capable of much wider use, and that it is possible that they may replace nickel steel for some purposes, at lower cost.

Passing over the chrome steels, we come to the alloys containing tungsten and molybdenum, these being of present interest in connection with the manufacture of high-speed tool steels.

Tungsten steel is readily made in the crucible, either by the use of ferro-tungsten or metallic tungsten. Ferro-tungsten is made in the electric furnace, and contains about 80 per cent. of tungsten and 8 to 9 per cent. of carbon. Metallic tungsten is made, either in the electric furnace or by the process of aluminothermy.

In his study of the properties of tungsten steels M. Guillet observes that the tungsten appears to exist in combination with the carbon as a carbide, at least when the content of tungsten is relatively high. The principal application of tungsten steel is in connection with the manufacture of tools, and the modern self-hardening high-speed steels contain 10 per cent. or more of tungsten. M. Guillet observes, however, that the presence of tungsten alone imparts but a small degree of air-hardening property to a steel, this requiring also the presence of chromium or manganese, and thus bringing the product out of the class of ternary steels. Tungsten steels have been advocated for springs, but M. Guillet believes that they are inferior for this purpose to steels containing silicon. Molybdenum steels are similar in their properties to the tungsten steels, and like them require the presence of chromium or manganese for the production of air-hardening tools. Apparently there is no especial reason for preferring molybdenum to tungsten, and the latter has the advantage of being less costly.

Among the other alloy steels discussed by M. Guillet are silicon, titanium, aluminum and tin alloys, concerning which reference must be made to the original memoir.

The general properties of the various ternary steels are arranged by M. Guillet in curves, and also summed up in a series of conclusions; mainly according to their structure.

Among the pearlitic alloys a certain number may well be employed in the place of carbon steels, this especially being the case with nickel steel, and probably with manganese steel. The martensitic steels offer fewer practical applications, although some of them may be found useful for special tools. The polyhedric steels have doubtless a brilliant future if they can be produced at a reasonable cost, but it will always be necessary to take into account their low elastic limits. Among the double carbide steels only those containing tungsten and molybdenum appear to be of practical importance, because of their special property of remaining very hard after tempering, this fitting them particularly for cutting tools.

At the present time there appears to be no practical application for graphitic steels.

THE ENGINEERING INDEX

"THE KEYSTONE IN THE ARCH OF APPLIED SCIENCE"

The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger division of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

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CIVIL ENGINEERING

BRIDGES.

Accident.

A Remarkable Accident to a Masonry Arch Bridge. From the *Zeitschrift des Vereines Deutscher Ingenieure.* An account of two arches, which were built three-hinged, slipping off their hinges, at Munich, Germany. 1800 w. Eng News —Oct. 27, 1904. No. 65814.

The Accident at the Maximilian Bridge in Munich (Der Bauunfall des Aüsseren Maximiliansbrücke in München). W. Dietz. Describing the displacement of one of the abutment hinges of a three-hinged masonry arch during erection. 3000 w. Zeitschr d Ver Deutscher Ing—Sept. 17, 1904. No. 65701 D.

Draw-Bridge.

An Interesting Draw-Bridge Built Mostly of Wood in Forty Working Days. Martin Scheiber. Description, with illustrations, of an interesting piece of engineering work on the White Line between Paterson and Hoboken, N. J. 1500 w. St Ry Rev—Sept. 20, 1904. No. 65473 C.

Foot Bridge.

The Ticonic Foot Bridge, Waterville,

We supply copies of these articles. See page 475.

Me. Illustrated description of a bridge crossing the Kennebec River. It is a steel structure with a 400-ft. suspended span and two through truss approach spans. 1800 w. Eng Rec—Oct. 15, 1904. No. 65564.

Highway Bridge.

The New Highway Bridge over the Thur at Billwil-Oberbüren (Die Neue Strassenbrücke über die Thur bei Billwil-Oberbüren). Describing a peculiar form of reinforced concrete bridge with two arches of 35 metres span each. 1200 w. Schweiz Bauzeitung—Oct. 1, 1904. No. 65767 B.

Railroad Bridge.

Forest Park Bridge of the Wabash at St. Louis. A. O. Cunningham. Illustrated description of a new ornamental structure in keeping with the surroundings, having a clear span of 70 feet. 1500 w. R R Gaz—Vol. XXXVII., No. 20. No. 65834.

Rebuilding.

Rebuilding a Wrecked Railroad Bridge at Easton, Pa. Describes the condition of the bridge after being wrecked, the temporary repairs to maintain traffic, and the final rebuilding. Ills. 3500 w. Eng Rec—Oct. 1, 1904. No. 65423.

Reinforced Concrete.

Concrete Test Arch of the Stuttgart Cement Works at Blaubeuren near Ehingen (Beton Probebogen der Stuttgarter Zementfabrik Blaubeuren in Ehingen). H. Hoch. Illustrated description of a test of a reinforced concrete arch of 20 metres span by loading it to destruction. 2000 w. Zeitschr d Ver Deutscher Ing—Sept. 24, 1904. No. 65708 D.

Skew Bridge of Armored Concrete. From *La Genie Civil.* Illustrated description of a bridge recently erected over the river Aisne, which is an interesting example of this type of construction. 4000 w. Engr, Lond—Oct. 7, 1904. No. 65577 A.

Suspension.

A Rational Form of Stiffened Suspension Bridge. Discussion of the paper by Gustav Lindenthal. 8800 w. Pro Am Soc of Civ Engrs—Oct., 1904. No. 65823 E.

Theory and Formulas for the Analytical Computation of a Three-Span Suspension Bridge with Braced Cable. Irving P. Church. Discussion of paper by Leon S. Morsseiff. 1200 w. Pro Am Soc of Civ Engrs—Oct., 1904. No. 65822 E.

Three-Hinged Arches.

A New Graphical Method for Stresses in Three-Hinged Arches. J. W. Balet. The explanation of the method considers only the three-hinged braced arch, although it is of general application to arches with or without hinges, braced or solid rib. 2800 w. Eng News—Oct. 20, 1904. No. 65637.

Viaduct.

Viaduct Erection on Section 10, New York Rapid Transit Railroad. Illustrates and describes some special features that have developed in the work, showing some traveler details. 2000 w. Eng Rec—Oct. 8, 1904. No. 65461.

CONSTRUCTION.

Excavating.

A Cable Power Scraper for Earth Excavation. C. G. Newton. Sketches, photographs and brief description of a steam scraper which has been used considerably on the Pacific coast, and has proved an economical machine. 500 w. Eng News—Oct. 20, 1904. No. 65635.

Girders.

A New Geometric Method of Computing the Forces Acting upon Continuous Girders (Nouvelle Determination Géométrique des Efforts dans les Poutres Droites à Travées Continues). Farid Boulad. Deriving equations and diagrams applicable to various conditions of loading. 1200 w. Génie Civil—Oct. 8, 1904. No. 65724 D.

Pillars.

The Buckling Formula of Rankine and Schwarz in the Form of a Graphical Diagram (Darstellung der Knickungsformel von Rankine und Schwarz in Form von Zeichnerischen Rechentafeln). Alexander Coulmas. Showing the method of drawing curves to represent the formula, and the transformation of these into straight lines. 2000 w. Zeitschr d Oesterr Ing u Arch Ver—Sept. 30, 1904. No. 65727 D.

Reinforced Concrete.

A Brief Mention of Some Minor Uses of Reinforced Cement in Subway Construction. Alfred Craven. A brief illustrated description of several adaptations of this material. 1000 w. Cement Age—Sept., 1904. No. 65357.

Concrete and Concrete-Steel. Abstract of a paper by A. Considère, presented before the Int. Engng. Cong., St. Louis. Discusses the materials used, arrangement, calculations of bending moments and shears, of sizes and deformations of reinforced beams, etc. 2700 w. R R Gaz—Vol. XXXVII., No. 20. No. 65835.

Economy in the Use of Steel Concrete. John B. Warren. Describes structures of steel-concrete construction with solid floors to show the saving in first cost as compared with the ordinary steel I-beam construction. Ills. 1800 w. Eng Rec—Oct. 15, 1904. No. 65566.

The Relation of the Ceiling to the Strength of the Girders in Reinforced Concrete Construction (Note sur la Par-

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ticipation du Hourdis à la Résistance des Nervures dans les Constructions en Béton Armé). Henry Lossier. An examination of floor and ceiling construction in reinforced concrete, showing the extent to which the ceiling itself aids in supporting the load. 1500 w. Schweiz Bauzeitung—Sept. 24, 1904. No. 65766 B.

See also Civil Engineering, Bridges.

See also Civil Engineering, Municipal Engineering.

Structural Work.

The Structural Design of Buildings. C. C. Schneider. Submits a set of specifications, for the structural work of buildings, for discussion and criticism, explaining some of the more important clauses and giving the reasons which led the writer to adopt them. 11000 w. Pro Am Soc of Civ Engrs—Sept., 1904. No. 65354 E.

Tunnels.

Some Notes on the Early History of the Hudson River Tunnel. S. D. V. Burr. Describes features of this work which have passed out of use, and are of historical value. Ills. 2500 w. RR Gaz—Vol. XXXVII., No. 18. No. 65554.

Subaqueous Tunnelling. Sir Alexander Binnie. Considers, exclusively, those tunnels which have had to be constructed in water-bearing strata in close proximity to the channel bed. Ills. 9500 w. Public Works—Oct. 15, 1904. No. 65622 D.

The Gravehals Tunnel, Norway. Illustrated description of the construction of a tunnel 5,300 metres long, which ranks as the seventh or eighth of the large tunnels of the world. 3300 w. Public Works—Oct. 15, 1904. No. 65625 D.

The Harlem River Tunnel Section of the New York Rapid Transit Railway. Illustrated description of the method of building the eastern half of the tunnel, radical changes having been made with the approval of the Chief Engineer. 2500 w. Eng News—Oct. 13, 1904. No. 65543.

MATERIALS OF CONSTRUCTION.

Cement.

Testing Portland Cement. James Nangle. Describes tests for soundness, firmness of grinding, and tensile strength to determine whether cement is safe to use. Ills. 3500 w. Aust Min Stand—Sept. 8, 1904. No. 65592 B.

Concrete.

Concrete in Subway Work. George W. Rice. An illustrated account of interesting concrete work, and methods of construction. 1200 w. Cement Age—Sept., 1904. No. 65356.

Concrete Mixers. Joseph Horner. Brief review of the development in these mixers and the cause, the designs and latest improvements. Ills. 3000 w. Public Works—Oct. 15, 1904. No. 65626 D.

Cost of Concrete Structures. H. M. Jones. Extracts from a paper presented to the Engng. Assn. of the South. A detailed statement of cost for concrete culverts and other small structures. 3500 w. R R Gaz—Vol. XXXVII., No. 19. No. 65655.

Metal Protection.

Protecting Low Overhead Structures from Gases and Blasts of Locomotives. Statements presented as the report of a committee at the convention of the Association of Railway Superintendents of Bridges and Buildings at Chicago. 1600 w. Eng News—Oct. 27, 1904. No. 65812.

Timber.

The Shrinkage and Warping of Timber. Harold Busbridge, in *Technics*. Illustrates and describes the behavior of wood treated in different ways. 1000 w. Sci Am Sup—Oct. 1, 1904. No. 65387.

MEASUREMENT.

Formula.

An Improved Formula for the High Masonry Dam. F. W. Crocker. Devises a method by which the processes of the American Formula may be abbreviated. 4200 w. Cal Jour of Tech—Sept., 1904. No. 65510 C.

Graduations.

A Cause of Errors in Graduated Circles (Sur une Cause de Variabilité des Erreurs de Division dans Certains Cercles Gradués). C. Bigourdan. An examination of the appearance of errors subsequent to graduation, caused by the unequal expansion of the materials. Iron is inferior to brass as a support for the graduated silver circle. 1000 w. Comptes Rendus—Sept. 26, 1904. No. 65747 B.

Level Recorder.

The Electric Long-Distance Water Level Recorder on the Wien River at Hadersdorf-Weidlingau (Der Elektrische Wasserstands-Fernmeldeapparat bei den Wienflussregulierungsanlagen in Hadersdorf-Weidlingau). Hans Baumeister. Describing an apparatus for enabling a continuous diagram of the water level in a reservoir to be recorded at a distance of half a kilometre. 3000 w. Zeitschr d Oesterr Ing u Arch Ver—Oct. 7, 1904. No. 65728 D.

Surveying.

The Completion of the Longitude Girdle of the Globe: Determination of the Difference in Longitude Between San Francisco and Manila. Edwin Smith. Gives results of the recent determination, describing the methods. 3500 w. Eng News—Oct. 6, 1904. No. 65479.

We supply copies of these articles. See page 475.

Tacheometry.

Notes on Tacheometry: A Comparison of Systems. Arthur L. Bell. A comparison of the two main systems of staff holding—staff vertical, and staff at right angles to line of sight. Ills. 1500 w. Engng—Oct. 21, 1904. No. 65836 A.

MUNICIPAL.

Pavements.

Convict Labor on a Standard Pavement. Describes the construction of a standard smooth pavement with the aid of convict labor in Fulton County, Georgia. Ills. 1800 w. Munic Engng—Oct., 1904. No. 65373 C.

Sewage Disposal.

Experiments in Purifying Brewery Refuse. From an account by H. Maclean Wilson of some experiments in the purification of brewery works at Rotherham. 1300 w. Eng Rec—Oct. 8, 1904. No. 65464.

Scientific Disposition of Sewage. Charles F. Holder. Describes the very successful disposition of sewage from the city of Pasadena, Cal. 1700 w. Sci Am—Oct. 22, 1904. No. 65641.

Sewage Purification Works for Small Populations. Arthur J. Martin. Read before the Inst. of San. Engrs. States some difficulties met with in dealing with sewage of small communities and the requirements of such plants. 5300 w. Builder—Oct. 22, 1904. No. 65849 A.

Sewage Purification Works Under Construction at Minworth Greaves, England. Information from a paper by A. Bryan, before the Assn. of Munic. Co. Engrs. Describes the intake chamber, experimental beds, percolating beds, the use of aerated floors, etc. 3800 w. Eng Rec—Oct. 8, 1904. No. 65462.

Sewage Treatment in Great Britain and Some Comparisons with Practice in the United States. M. N. Baker. Introduction to recently published works. Shows the dissimilarity in the conditions affecting the treatment, and gives a summary of the main features of British works recently visited, with conclusions and comments. 2500 w. Eng News—Oct. 6, 1904. No. 65480.

The Royal Commission on Sewage Disposal. A review of the Commission's fourth report. 2800 w. Engr Lond—Oct. 7, 1904. Serial. 1st part. No. 65578 A.

The Sewage Testing Station at Columbus, Ohio. John H. Gregory. An illustrated detailed description of the station and its equipment. 2400 w. Eng News—Oct. 20, 1904. No. 65639.

Sewers.

A Concrete-Steel Sewer at Harrisburg, Pa. An illustrated description of the design and construction of the Paxton Creek intercepting sewer, with report of cost. 3500 w. Eng Rec—Oct. 15, 1904. No. 65561.

Diagram Giving Dimensions of Conduits of Equal Capacity. Gives a convenient diagram for determining quickly the dimensions of horse-shoe shaped cross sections of equivalent discharging capacity to given circular sections, and vice versa. 1100 w. Eng Rec—Oct. 8, 1904. No. 65466.

Reinforced Concrete Sewers in Wilmington, Del. Photographs and drawing, with description of the work. 1200 w. Munic Engng—Oct., 1904. No. 65374 C.

Sewer Trenching and Gas Mains. Notes based upon a paper read before the Eastern Counties Gas Managers' Association, by E. G. Smithard, concerning difficulties met with in constructing a sewerage system at King's Lynn. 2000 w. Eng Rec—Oct. 22, 1904. No. 65667.

Underground Structures.

Losses in Underground Municipal Structures. Prof. A. Prescott Folwell. Read before the Am. Soc. of Munic. Imp. Discusses the enormous loss and inconvenience caused by present methods of managing street surface and sub-surface structures. Considers the sources of loss separately, and possible remedies. 2500 w. Eng Rec—Oct. 15, 1904. No. 65565.

WATER SUPPLY.

Copper Treatment.

The Use of Copper Sulphate to Prevent Algæ Growths at Hanover, N. H. Prof. Robert Fletcher. Brief description of this manner of purification and its complete success. 700 w. Eng News—Oct. 27, 1904. No. 65815.

Deposits.

Deposits in Water Pipes and Other Channels. Notes from a paper by Prof. James Campbell Brown, read before the Inst. of Civil Engrs. (England). Considers incrustations on imperfectly protected iron pipe, and deposits on the inner surface of iron pipes, culverts, and other channels. 1800 w. Eng Rec—Oct. 1, 1904. No. 65422.

Ground Water.

Some Geological Principles of Subterranean Water Supply. F. J. H. Merrill. Discusses deep wells in soft rocks, and deep wells in hard rocks. 1100 w. Eng News—Oct. 20, 1904. No. 65640.

Purification.

Coagulation Plant at the Settling Basins at St. Louis, Mo. E. E. Wall. Describes the new process in use at St. Louis for clarifying and purifying the Mississippi River water. 1800 w. Eng News—Oct. 27, 1904. No. 65816.

We supply copies of these articles. See page 475.

The Purification of Water. Prof. John M. Ordway. Extract. Remarks on methods used for removing color, iron, hardness, etc. 2800 w. Am Mach—Vol. 27, No. 39. No. 65361.

Reservoir.

Lake Cheesman Dam and Reservoir. G. S. Williams. Continued discussion of paper on this subject by Charles L. Harrison, and Silas H. Woodard. 7500 w. Pro Am Soc of Civ Engrs—Sept., 1904. No. 65355 E.

Troy, N. Y.

The New Water Supply of Troy, N. Y. William G. Raymond. Reviews the past history of the supply and gives an illustrated description of recent important engineering work to increase the supply. 6300 w. Eng News—Oct. 6, 1904. No. 65477.

Water-Works.

The New Water-Works of East Orange, N. J. Illustrated description of a municipal system comprising artesian wells, a pumping station, a 24-in. river main 5 miles in length from the pumping station to a concrete reservoir, and a gravity distribution system. 3000 w. Eng Rec—Oct. 22, 1904. No. 65668.

WATERWAYS AND HARBORS.

Canals.

Proposed Canal to Connect Montreal with the Head of Lake Huron. Day Allan Willey. An explanation of the discussed plan and the advantages it would give. 1600 w. Sci Am Sup—Oct. 29, 1904. No. 65819.

Channel.

Transport Across Maritime Channels. G. Leinekugel le Cocq. An illustrated review of the main ways of establishing communication between opposite shores of maritime waterways in such a manner as not to interfere with the passage of vessels having lofty masts. 5000 w. Public Works—Oct. 15, 1904. No. 65627 D.

Dam.

The New Charles River Dam and Basin at Boston, Mass. J. Albert Holmes. An account of the plans being matured for the construction of this dam, stating the conditions. 1100 w. Eng News—Oct. 6, 1904. No. 65478.

Docks.

New Graving Dock at Helburn. Illustrated detailed description. 1500 w. Engr, Lond—Oct. 21, 1904. No. 65844 A.

The Design of a Dry Dock. Alfred W. Young. Read before the Junior Inst. of Engrs. Considers the subject chiefly in regard to stability of structure rather than the elements effecting the outline. Ills. 5000 w. Engng—Sept. 30, 1904. No. 65526 A.

Drainage.

The Drainage of Inner Basins, Mississippi Levee System. Charles Le Vasseur. Slightly condensed from a paper published in the *Journal of the Memphis Engineers' Society*. Considers the drainage of the areas inclosed by the completion of the levees, and having no outlet. Describes the method of disposing of this water. 1800 w. Eng News—Oct. 27, 1904. No. 65813.

Dredge.

The Hydraulic Dredger. "J. Israel Tarte." A. W. Robinson. Read before the Canadian Soc. of Civ. Engrs. A detailed account of the dredger and its work, with illustrated description. 7500 w. Engng—Oct. 21, 1904. No. 65840 A.

Groynes.

Groynes. A. T. Walmisley. Illustrated article describing various forms of construction used, and discussing the systems, their good and ill effects. 4200 w. Public Works—Oct. 15, 1904. No. 65624 D.

Harbor Plant.

See Mechanical Engineering, Internal-Combustion Motors.

Nile.

The River Nile and Irrigation in Egypt. An editorial discussion of the report of Sir William Garstin. 3800 w. Engng—Oct. 7, 1904. No. 65574 A.

Quays.

Skeleton Quays for Docks, Harbors, Wharfs, etc. R. C. Bullock. Describes quays designed to carry a load from 3 cwt. to 5 cwt. per sq. ft. without using superfluous material, and so decreasing the cost. Ills. 600 w. Prac Engr—Sept. 30, 1904. No. 65517 A.

MISCELLANY.

Explosion.

The Antwerp Petroleum Explosion. An illustrated account of the explosion on August 26, discussing the arrangements for storage. 1600 w. Engng—Oct. 21, 1904. No. 65839 A.

Hospital Engineering.

Engineering at Guy's Hospital. Begins a description of a hospital plant that has recently been remodeled. 1500 w. Engr, Lond—Oct. 14, 1904. Serial. 1st part. No. 65696 A.

Simplon.

The Simplon Tunnel. Francis Fox. A brief illustrated account of this work, the difficulties encountered, and conquered, the present condition, and the probable junction of the headings. 1500 w. Nature —Oct. 27, 1904. No. 65939 A.

We supply copies of these articles. See page 475.

ELECTRICAL ENGINEERING

COMMUNICATION.

Accumulators.

The Use of Accumulators to Supply Current for Microphones in Telephony (Akkumulatoren als Stromquelle für die Mikrophone der Fernsprechstellen). Ludwig Brückmann. Discussing the substitution of central-station storage batteries for local primary batteries for telephones. 3000 w. Elektrotech Zeitschr—Sept. 22, 1904. No. 6573º B.

Conductors.

The Transposition of Electrical Conductors. Frank F. Fowle. Mathematical and practical discussion of the transposition of telephone and of power circuits to avoid electric and magnetic disturbances. 3500 w. Trans Am Inst of Elec Engrs—Oct. 28, 1904. No. 65825 D.

Duplex.

The Duplex Balancing of Telegraph Cables. W. Gaye. Notes arising out of a little study of the operational methods of Mr. Oliver Heaviside in connection with the balancing of cables for the purpose of duplex telegraphy. 2500 w. Elect'n, Lond—Sept. 23, 1904. Serial. 1st part. No. 65447 A.

Japan.

Telegraph and Telephone Systems in Japan and Central Stations. From *L'Electrician*. Brief account showing how rapidly the Japanese adopted and installed telegraph and telephone lines, and their facility in operating and constructing them. 1200 w. Sci Am Sup—Oct. 15, 1904. No. 65545.

Space Telegraphy.

A Recent Wireless Telegraph Patent. Describes an "Improved Mode of and Apparatus for Producing and Detecting Hertzian Oscillations," patented by J. Nevil Maskelyne. 3000 w. Elect'n, Lond—Oct. 14, 1904. No. 65690 A.

Electrolytic Receivers in Wireless Telegraphy. Dr. Leede Forest. Briefly reviews the field of cohering indicators of electric waves, and considers recent investigations leading to forms of receivers based on the electrolytic principle which are attracting much attention. General discussion. 7000 w. Jour Fr Inst—Oct., 1904. No. 65435 D.

The Theory of Wireless Telegraphy. Dr. John Stone Stone. Presented before the Inst. Elec. Cong. at St. Louis. Gives the popular theory and the working theory of that form of wireless telegraphy in which electrical vibrations are set up in electrical oscillators whose axes are normal to the earth's surface, and which are connected to the earth's surface at their lower extremities. 5000 w. Elec Rev, N Y—Oct. 15, 1904. No. 65652.

Wireless Telegraph Aerial Wires and Earths. A. Frederick Collins. From advance sheets of a work in press. Gives illustrated descriptions of the forms of ordinary aerials, with explanation of the theories advanced. 3600 w. Elec Wld and Engr—Oct. 15, 1904. No. 65605.

Wireless Telegraphy at the St. Louis Exposition. Lloyd Marshall. An illustrated article describing the stations and their working. 1000 w. Cassier's Mag—Oct., 1904. No. 65350 B.

Telautograph.

Telautograph. James Dixon. Reviews the development of electrical transmission of handwriting, and describes the telautograph and its recent improvements, operation, etc. 3500 w. Trans Am Inst of Elec Engrs—Oct., 1904. No. 65608 D.

Telegraphy.

Mercadier's System of Attuned Telegraphy. An explanation of the tuning-fork system for manifold telegraphy. Ills. 2500 w. Sci Am Sup—Oct. 8, 1904. No. 65484.

Telephony.

Planning a Telephone System. Samuel G. McMeen. Read at the St. Louis convention of the Ind. Tel. Assn. of the U. S. A discussion of rules to be applied in planning a telephone system at minimum costs. 2500 w. Elec Rev, N Y—Sept. 8, 1904. No. 65505.

Wiring.

Interior Wiring for Telephones. Charles H. Coar. Discusses points of importance, and gives rules applicable in many cases. 2200 w. Elec Wld and Engr—Oct. 15, 1904. No. 65604.

DISTRIBUTION.

Arresters.

An Experiment to Illustrate the Principle of Horn Arresters. A. E. Moore. Describes an experiment made to determine whether connection or electromagnetism plays the more important part. The result shows that connection plays only a small part. 900 w. Elec Engr, Lond—Oct. 7, 1904. No. 65583 A.

Conductors.

Approximate Methods of Computing Conductors for a Given Loss of Energy

We supply copies of these articles. See page 475.

(Näherungsverfahren zur Berechnung Elektrischer Leitungen bei Gegebenen Arbeitsverlust). Léopold Rosenbaum. A mathematical discussion showing methods of abridging the work of computation. 2000 w. Zeitschr f Elektrotech—Oct. 2, 1904. No. 65757 D.

Regulation.

A New Method of Regulating the Pressures in a Distribution System (Ein Neues Verfahren zur Spannungsregelung in Stromverteilungsnetzen). Dr. E. Müllendorf. A discussion of the varying demands of different parts of a city for current, and the necessity of taking this into account in the distributing system. 3000 w. Elektrotech Zeitschr—Oct. 6, 1904. No. 65742 B.

Rotary Converters.

Practical Management of Rotary Converters. F. P. de Wilde. An explanation of two general methods of operating rotaries. Diagrams. 2200 w. Am Elect'n—Oct., 1904. No. 65434.

Three-Phase.

The Question of Excess Pressure in Three-Phase Installations (Ein Beitrag zur Frage der Ueberspannungen in Dreiphasenstrom Anlagen). P. Humann. A discussion of the danger to a cable by excess of pressure caused by the burning out of a fuse or other disturbance of balance. 2000 w. Elektrotech Zeitschr—Oct. 13, 1904. No. 65744 B.

Three-Wire.

Three-Wire Distribution. F. Hardie Jeannin. Description of the three-wire system and its modifications, discussing its good and bad features, its applications, etc. Diagrams. 4000 w. Elec Wld and Engr—Oct. 22, 1904. No. 65678.

ELECTRO-CHEMISTRY.

Electrolysis.

Differences in the Electrolysis of Potassium Chloride and Sodium Chloride. F. Winteler. Discusses in detail the differences stated. 2000 w. Elec Chem Ind—Oct., 1904. No. 65502 C.

Iron.

Electrolytic Iron (Ueber das Elektrolyteisen). A .Skrabal. A study of the physical and chemical properties of iron produced by electrolytic deposition. 2000 w. Zeitschr f Elektrochemie—Sept. 23, 1904. No. 65772 G.

ELECTRO-PHYSICS.

Conduction.

The Conduction of Electricity in Mercury Vapor. A. P. Wills. Abstract of an article in the *Physical Review* of New York. Experimental investigation of the conducting properties of the "positive column." 3800 w. Elect'n, Lond—Oct. 21, 1904. No. 65846 A.

Hysteresis.

The Energy Dissipated in Iron by Hysteresis at High Frequencies (Sur l'Energie Dissipé dans le Fer par Hysteresis aux Fréquences Elevees). C. E. Guye & A. Schidlof. Tabulated results of experiments, showing that the energy consumed is independent of the speed. 800 w. Comptes Rendus—Sept. 26, 1904. No. 65748 B.

Radioactivity.

The Phenomena of Radioactivity (Ueber die Erscheinungen der Radioaktivität). Dr. Gottfried Diemer. A review of radioactive emanations and the methods employed for observation and study. Two articles. 4000 w. Zeitschr f Elektrotechnik—Sept. 25, Oct. 4, 1904. No. 65756 each D.

Striking Distance.

The Law of Electric Striking Distance Through Atmospheric Air (Ueber das Elektrische Durchschlagsgesetz für Atmosphärische Luft). Dr. B. Walter. Discussing electric discharges through dielectrics, and giving tables showing the voltages required to overcome the resistance of various distances in air. 2000 w. Elektrotech Zeitschr—Oct. 6, 1904. No. 65743 B.

GENERATING STATIONS.

Commutation.

Commutation of Continuous-Current Generators and Motors. G. A. Neild and P. E. Banting. Read before the Rugby Engng Soc. Deals only with machines having slot-wound armatures and carbon brushes. Discusses the effect of weakening the fields of dynamos and motors, reactance voltage, crane motors, and errors of construction. Ills. 5500 w. Elec Engr, Lond—Sept. 23, 1904. No. 65443 A.

Generators.

The Design of Generators for Electric Power Transmission Work. David B. Rushmore. An explanation of the characteristics and relations of this machine. 5500 w. Eng News—Oct. 27, 1904. No. 65811.

Germany.

The Altbach Deizisau Central Station. Dr. Alfred Gradenwitz. Illustrated description of an installation supplying power and light to numerous towns of the Neckar and Fils Valleys in Southern Germany. 2500 w. Elec Rev, N Y—Oct. 22, 1904. No. 65664.

Hydro-Electric.

The Etzel Power Station (Von Etzelwerk). An account of the proposed hydro-electric station on the Upper Sihl

near Zürich, with topographical map, and estimates of cost. 1500 w. Schweiz Bauzeitung—Oct. 1, 1904. No. 65768 B.

The Puyallup River Water Power Development Near Tacoma, Washington. Illustrated detailed description of a generating plant to supply electric power to the cities of Seattle and Tacoma, Wash. 6000 w. Eng News—Sept. 29, 1904. No. 65370.

The Works of the Ontario Power Company of Niagara Falls. Illustrated detailed description of a plant on the Canadian side of the river, planned for at least 180,000 h. p. ultimate capacity. 2700 w. Eng Rec—Oct. 8, 1904. Serial. 1st part. No. 65463.

See also Street and Electric Railways.

London.

The Lot's Road Generating Station of the Underground Electric Railways Co. of London. Illustrated description of the largest station of its kind in Great Britain. 3500 w. Elect'n, Lond—Oct. 21, 1904. No. 65845 A.

Power Station.

Largest Steam-Driven Power Station in the World. Illustrates and describes the steam plant of the New York Interborough Rapid Transit Company. 6700 w. Am. Elect'n—Oct., 1904. No. 65432.

Power Plant of the Intramural Railway at the St. Louis Exposition. Detailed description with illustrations. 4500 w. Eng News—Oct. 13, 1904. No. 65542.

The Power House of the Subway Division, Interborough Rapid Transit Co., New York. An illustrated comprehensive description of this station. 5800 w. Eng Rec—Oct. 1, 1904. Serial. 1st part. No. 65421.

Storage Battery Plant.

The Toronto Railway Storage Battery. An illustrated description of the plant, with a statement of the advantages obtained. 1500 w. Can Elec News—Oct., 1904. No. 65644.

Transformers.

Experiments with a Transformer of High Capacity (Versuche mit einem Transformator Hoher Eigenkapacität). Leo Lichtenstein. Data and results of test with a special transformer of high electrostatic capacity in the secondary. 2500 w. Elektrotech Zeitschr—Oct. 6, 1904. No. 65741 B.

Operation of the Series Transformer. Edward L. Wilder, in the *Electric Club Journal.* An explanation of the operation, and the difference between the series and the shunt. 1000 w. Elec Rev, N Y—Oct. 1, 1904. No. 65400.

Transformer Testing for Central Stations. S. E. Johanneson. Gives the various tests which may be applied to transformers. Diagrams. 2300 w. Engr, U S A—Oct. 1, 1904. Serial. 1st part. No. 65426 C.

Turbo-Generators.

An Interesting French Steam-Driven Turbine Plant. An illustrated detailed description of the power station of Neuchatel. 2800 w. Am Elect'n—Oct., 1904. No. 65431.

The 5,000-Horse-Power Three-Phase Turbo-Alternator at the Porta Volta Electric Supply Station of Milan. Illustrated description. 1000 w. Sci Am Sup—Oct. 1, 1904. No. 65388.

New Turbo-Generator Station of the Detroit Edison Company. Illustrates and describes a plant in which Curtis turbines are the prime movers, arranged to run either condensing or non-condensing. The plant is electrical throughout and strictly alternating-current. 3300 w. Engr, U S A—Oct. 1, 1904. No. 65424 C.

See Also Mechanical Engineering, Steam Engineering.

LIGHTING.

Illumination.

Street Lighting. A. S. Hatch. Read before the Int. Assn. of Munic. Elect'ns. Remarks on the various methods of electric lighting for streets. 3000 w. Munic Engng—Oct., 1904. No. 65375 C.

Nernst.

Tests of the Nernst Lamp by the Electric-Light Inspector of Hamburg (Untersuchungen an Nernstlampen seitens des Inspektorats der Elektrischen Beleuchtung in Hamburg). H. v. Gaisberg. With tables showing the life, current consumption, and illuminating power of the lamps tested. 1200 w. Elektrotech Zeitsch—Oct. 13, 1904. No. 65745 B.

Review.

Recent Progress in Electric Lighting (Récent Progrès de l'Eclairage Electrique). M. Roberjot. A review of recent improvements, including arc, mercury vapor, magnetite, incandescent, Nernst, and osmium lamps. 6000 w. Bull Soc d'Encour—Aug., 1904. No. 65754 G.

MEASUREMENT.

Chronograph.

A New Electro-Chronograph. David Owen. Brief, illustrated description. 900 w. Elect'n, Lond—Sept. 30, 1904. No. 65524 A.

Magnetograph.

A Quartz-Thread Vertical Force Magnetograph. W. Watson. An illustrated description of an instrument for recording rapid vibrations of vertical force, which has been actually run for some time. 2500 w. Sci Am Sup—Oct. 8, 1904. No. 65485.

Oscillograph.

Some Applications of the Oscillograph

(Einige Anwendungen des Oscillographen). Prof. Franz Wittman. Describing the use of the instrument for observing electric and magnetic waves and cycles. 4000 w. Elektrotech Zeitschr—Oct. 13, 1904. No. 65746 B.

Photometers.

On the Theory of the Matthews and the Russell-Léonard Photometers for the Measurement of Mean Spherical and Mean Hemispherical Intensities. Edward P. Hyde. A brief résumé of a theoretical investigation of the Matthews and the more recent Russell-Léonard integrating photometers. 1800 w. Elec Wld & Engr—Oct. 22, 1904. No. 65679.

Resistance.

The Thiermann Resistance Coil and Compensator (Messdraht und Kompensator nach Prof. Wilhelm Thiermann, Hannover). Dr. Wilhelm Schüppel. Describing an improved apparatus for comparing resistances, claimed to give accurate results to six significant figures. 3000 w. Elektrotech Zeitschr—Sept. 29, 1904. No. 65739 B.

Solenoids.

Cores for Solenoids (Ueber Solenoid-Kerne). F. G. Pero. Discussing the construction of solenoids for use in connection with electrical measuring instruments, including the best form and choice of material. 1200 w. Zeitschr f Elektrotechnik—Oct. 9, 1904. No. 65758 D.

Testing.

Notes on Testing. M. A. Sammett. Calls attention to the importance of temperature rise of apparatus under load. 1800 w. Can Elec News—Oct., 1904. No. 65645.

MOTORS.

Alternating Motors.

Alternating Current Commutator Motors. A. S. M'Allister. Reviews the properties common to all commutator type, alternating-current machines, and discusses the performance of repulsion motors. 3300 w. Sib Jour of Engng—Oct., 1904. No. 65671 C.

Design.

Design and Construction of Small Dynamos and Motors. Cecil P. Poole. The first of a series of articles aiming to enable amateurs to build any size of direct-current dynamos or motor, from 3 inches to 16 inches armature diameter without the necessity of mastering the science of dynamo design. 1000 w. Am Elect'n—Oct., 1904. Serial. 1st part. No. 65433.

Induction Motors.

The Computation of the Lines of Magnetic Force in Induction Motors (Die Berechnung der Streuung und des Magnetisierungsstromes von Drehstrommotoren). Dr. G. Benischke. Deriving general formulas applicable to any case without involving the use of empirical coefficients obtained from special experiments. 4000 w. Elektrotech Zeitschr—Sept. 22, 1904. No. 65737 B.

The Design of Induction Motors. A. Press. A mathematical investigation. 1000 w. Elec Rev, Lond—Oct. 14, 1904. No. 65689 A.

The Starting of the Heyland Single-Phase Induction Motor. A. Boyd. Describes experiments carried out with the object of showing the distribution of the flux in the air-gap before and after the rotor circuits are closed, and to explain how the latter distribution is brought so that a torque is produced in a definite direction. 3500 w. Elect'n, Lond—Sept. 23, 1904. No. 65448 A.

Railway Motor.

Exhibition of the General Electric Company's Compensated Railway Motor Equipment. Gives illustrations showing features of this new equipment recently exhibited on the Ballston extension of the Schenectady Railway. The object is to adapt electric traction to longer lines through the use of the alternating current. 1200 w. Am Mach—Vol. 27, No. 39. No. 65359.

Regulation.

The Speed Regulation of Three-Phase Motors by Pole Changing. J. K. Sumec. Abridged translation from the *Zeitschrift für Elektrotechnik*. Discusses the regulation of induction motors by varying the magnetic field. Diagrams. 1200 w. Elec Engr, Lond—Oct. 7, 1904. No. 65585 A.

Single Phase.

The Theory of the Single-Phase Non-Synchronous Motor (Zur Theorie des Asynchronen Einphasenmotors). Paul Müller. A mathematical and graphical study for different arrangements of the magnetic field. 4500 w. Electrotech Zeitschr—Sept. 29, 1904. No. 65740 B.

Starting.

Notes on Motor-Starting Switches. Considers the requirements of a good starting switch, and begins a detailed study of the construction of some of the higher-class starters used for special purposes. 4000 w. Elec Engr, Lond—Oct. 7, 1904. Serial. 1st part. No. 65582 A.

Synchronous Motors.

Discussion on "Synchronous Motors for the Regulation of Power-Factor and Line Voltage." Discussion at Chicago of paper by B. G. Lamme. 6500 w. Trans Am Inst of Elec Engrs—Oct., 1904. No. 65611 D.

TRANSMISSION.

Cable Losses.

On the Heating of Three-Phase Cable

We supply copies of these articles. See page 475.

Sheaths. M. B. Field. A discussion of the rotating field surrounding a three-phase cable, showing the existence of a torque between the conductors and sheath, with consequent losses. 2000 w. Elec Rev, Lond—Sept. 23, 1904. No. 65445 A.

Direct Current.

Direct Current Transmission at 70,000 volts. A. Steens. An account of interesting experiments recently carried out by the Compagnie de l'Industrial Electrique at Mécanique of Geneva, with a view to ascertaining the extent to which insulators would withstand the direct current as compared with alternating current. 2500 w. Elec Rev, Lond—Oct. 14, 1904. No. 65687 A.

Experiments with Continuous Currents at High Tensions (Expériences sur les Courants Continus à Haute Tension). An account of experiments at Geneva with the transmission of continuous currents at pressures as high as 70,000 volts. 1500 w. Genie Civil—Sept. 17, 1904. No. 65717 D.

High Tension.

High-Tension Lines. H. Parker Gibbs. On the importance of good line construction, and other points essential for successful working. Ills. 2800 w. Elec Rev, N Y—Oct. 22, 1904. No. 65663.

Lightning Arresters.

Protection from Lightning. Prof. Dr. Fr. Neesen. A lecture delivered before the Electrochemical Society of Leipzig. An illustrated review of the laws governing the construction of lightning protectors. Considers protectors for buildings, arresters for low-potential circuits, and for high-potential circuits. 3800 w. Sci Am Sup—Oct. 22, 1904. No. 65643.

Long Spans.

Discussion on "Long Spans for Transmission Lines." Discussion at Chicago of the paper by F. O. Blackwell. 9500 w. Trans Am Inst of Elec Engrs—Oct., 1904. No. 65610 D.

Norway.

The Electric Power-Transmission Plant at the Waterfalls of Kykkelsrud, Norway. Einar Boye. Illustrated detailed description. 2500 w. Elec Rev, N Y—Oct. 1, 1904. No. 65399.

Three-Phase.

The Three-Phase 40,000-Volt Power Transmission from Gromo to Nembro (Lombardia). States the conditions which had to be fulfilled and gives an illustrated description of the carrying out of the scheme, with reasons for the adoption of an extra high working pressure. 5400 w. Elec Rev, Lond—Sept. 23, 1904. No. 65446 A.

MISCELLANY.

Address.

President's Address. Bion J. Arnold. Address at the St. Louis meeting discussing how to determine the dividing line between steam and electricity in railway operation. 3300 w. Trans Am Inst of Elec Engrs—Oct., 1904. No. 65609 D.

Electrical Law.

Electrical Law in the Colonies and India. Synoposis of electrical legislation in the more important British colonies. 3000 w. Elec Rev, Lond—Sept. 30, 1904. Serial. 1st part. No. 65523 A.

Electrical Legislation. W. Valentine Ball. A discussion of the effect of British legislation upon the electrical industry, and the effort being made to bring about a reform. 3800 w. Trac & Trans—Oct., 1904. No. 65534 E.

INDUSTRIAL ECONOMY

Education.

A New Departure in Technical Education. E. H. Roberton. Brief, illustrated description of the experimental mine at Birmingham University. 900 w. Page's Mag—Oct., 1904. No. 65567 B.

Notes on Engineering Education (Considérations sur l'Enseignement de la Mécanique). Prof. J. Boulvin. A discussion of the importance of combining practical with theoretical training in the education of the engineer. Serial. Part I. 4000 w. Revue de Mécanique—Sept., 1904. No. 65731 E + F.

Notes on the Technical Intermediate Schools (Betrachtungen über technische Mittelschulen). Adolf Lippmann. A review of the curriculum of the preparatory school, discussing the work of private institutions in Germany. Serial. Part I. 3500 w. Zeitschr d Ver Deutscher Ing—Oct .1, 1904. No. 65711 D.

Technical Education in the United States. P. Krenzpointner. Translated from *Zeitschrift des Vereines Deutscher Ingenieure*. A general review of the educational system of the country. 3000 w. Bul Int Ry Cong—Sept., 1904. No. 65620 E

Labor.

Application of Scientific Methods to the Labor Problem. H. L. Gantt. Read before the Int. Cong. of Arts and Sciences

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at St. Louis. Reviews briefly the development of the manufacturing industries, and suggestions for a scientific study of the proper amount of work to be required in a day, and the compensation. 2300 w. Am Mach—Oct. 20, 1904. No. 65630.

Laboratory.

The Mechanical Plant of the New Technical High School at Danzig (Die Maschinenanlagen der Neuen Technischen Hochschule zu Danzig). W. Josse. A very full account of the new plant of the mechanical laboratory, including steam, hydraulic, pneumatic and electrical equipment. 10,000 w. 2 plates. Zeitschr d Ver Deutscher Ing—Oct. 8, 1904. No. 65713 D.

Patent Rights.

The Patent Rights of Employers and Workmen. Discusses how far an inventor is entitled to claim the fruits of the workman's labor and ingenuity, stating several cases in their legal aspect. 3500 w. Engr, Lond—Sept. 30, 1904. No. 65528 A.

Statistics.

An Engineering Problem (Eine Ingenieuraufgabe). H .Häbich. A discussion of the industrial problems in connection with manufacturing in various countries, dealing especially with the effect of American competition with Germany. 4500 w. Zeitschr d Ver Deutscher Ing—Sept. 17, 1904. No. 65704 D.

MARINE AND NAVAL ENGINEERING

Arctic Service.

Peary's New Ship for Work in Arctic Seas. An illustrated description of this specially constructed vessel, designed to meet every emergency of the Arctic climate. 1500 w. Sci Am—Oct. 8, 1904. No. 65482.

Battleships.

H. M. S. Black Prince. Illustration, with description, and comparison with the French Renan and the U. S. A. California. 800 w. Engr, Lond—Oct. 14, 1904. No. 65698 A.

Italian First-Class Battleship "Regina Margherita." Illustration, with description. Also gives one of the engines. 700 w. Sci Am Sup—Oct. 8, 1904. No. 65483.

Machinery of the Italian Battleship Regina Margherita. Description, with illustrations and report of trials. 1600 w. Marine Engng—Oct., 1904. No. 65407 C.

Cruiser.

The Japanese Armored Cruiser "Kasuga." Illustrations, with comments. 500 w. Engng—Oct. 21, 1904. No. 65838 A.

Fleet Auxiliaries.

Auxiliaries of a War Fleet with Special Reference to Recent Additions to the British Navy. Archibald S. Hurd. Shows the necessity of providing for this service and gives particulars of the more important recent types added to the British Navy. 5000 w. Cassier's Mag—Oct., 1904. No. 65347 B.

Gas Power.

See Mechanical Engineering, Internal-Combustion Motors.

Launch.

Launch of Battleships Connecticut and Louisiana. Illustrations, with brief descriptions and information of interest. 700 w. Marine Engng—Oct., 1904. No. 65408 C.

The Launching of the United States Battleship Connecticut. Illustrated description of this vessel and her equipment, with details of the contest between the work in the government navy yard and on a sister ship in a private shipbuilding establishment. 3700 w. Ir Age—Oct. 6, 1904. No. 65467.

Launch Motor.

See Mechanical Engineering, Internal-Combustion Motors.

Lifeboats.

Some New Types of Lifeboats. An illustrated article describing the adaptation of the gasoline motor to the requirements of lifeboat work. Also describes the boat invented by M. Albert Henry. 3800 w. Sci Am—Oct. 8, 1904. No. 65481.

Liquid Fuel.

See Mechanical Engineering, Steam Engineering.

Schooner.

Pacific Coast Steam Schooner Likelike. Illustrated detailed description. 1200 w. Marine Engng—Oct., 1904. No. 65410 C.

Shipbuilding.

Messrs. Beardmore's New Shipyard and Engine Works. Illustrated description of fine new works on an ideal site on the River Clyde, and their equipment. 5000 w. Engng—Oct. 7, 1904. No. 65570 A.

The Slips of the Vulcan Works at Stettin (Die Hellinge der Stettiner Maschinenbau, A. G. Vulcan). A description of the ways and overhead travelling crane equipment over the shipbuilding slips at the Vulcan Works. 1800 w. Zeitschr d Ver Deutscher Ing—Oct. 1, 1904. No. 65710 D.

Steamship.

The Freight and Passenger Steamer Prince Sigismund (Der Fracht und Per-

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sonendampfer "Prinz Sigismund"). W. Kaemmerer. Illustrating and describing a new vessel built for the South American trade of the Hamburg-American Line. 1200 w. 1 plate. Zeitschr d Ver Deutscher Ing—Sept. 24, 1904. No. 65706 D.

Torpedo Explosions.

The Effect of Torpedo Explosions. Interesting illustrations of a Japanese vessel torpedoed and left to sink, but finally saved, with brief notes. 400 w. Engng—Oct. 7, 1904. No. 65572 A.

Tugboats.

Economic and Earning Possibilities of the Ocean-Going Tugboat. Discusses briefly the development and improvements in towboats, and the probability of their being used more extensively for coast service. 1800 w. Naut Gaz—Oct. 6, 1904. No. 65497.

Tugboats and Towing in the United States. Illustrates types of boats used on harbors, lakes and rivers, and reviews the history of this indusry. 1800 w. Naut Gaz—Oct. 6, 1904. No. 65496.

Turbine Propulsion.

How the Victorian Looks. Illustrations, with description of this turbine vessel built for service on the Atlantic, in the Candian mail service. 2300 w. Marine Rev—Sept. 29, 1904. No. 65406.

The First Turbine Atlantic Liner. An illustrated description of the "Victorian," the first of two turbine-driven ships ordered by the Allan Line. 1100 w. Page's Mag—Oct., 1904. No. 65568 B.

Yacht.

The Auxiliary Power Yacht "Mollihawk II." Illustrates and describes two vessels in which the sail and power systems of propulsion are combined. They are fitted with oil engines. 2000 w. Engng—Oct. 7, 1904. No. 65571 A.

MECHANICAL ENGINEERING

AUTOMOBILES.

Air-Cooling.

Progress of the Air-Cooled Motor. C. C. Longridge. Reviews the present disabilities of the air-cooled high-powered motor, and discusses the progress that has been made. 2000 w. Engr, Lond—Sept. 30, 1904. No. 65530 A.

Commercial Vehicles.

The Milnes-Daimler Omnibuses and Commercial Vehicles. Begins an illustrated description of this class of vehicles, as designed by the company named. 1100 w. Auto Jour—Sept. 24, 1904. Serial. 1st part. No. 65438 A.

Cup Race.

First Competition for the Vanderbilt International Automobile Cup. An illustrated account of the recent race on Long Island. 2200 w. Sci Am—Oct. 22, 1904. No. 65642.

How the Vanderbilt Cup Race Was Won. A number of articles giving illustrated detailed accounts of the first race for the Vanderbilt Cup, won by a Panhard racer for France. 30700 w. Automobile—Oct. 15, 1904. No. 65559.

Electric Vehicles.

Costs of Electric Automobilism. Robert H. Smith. A discussion of the cost of running these vehicles, giving experience in London, and giving the conclusions of the writer. 2300 w. Engr, Lond—Sept. 30, 1904. No. 65527 A.

Gordon-Bennett Cup.

The Gordon-Bennett Cup for 1905. States propositions of Marquis de Dion for changes in the rules for this international championship, with opinions of French and British. 2000 w. Autocar—Oct. 15, 1904. No. 65680 A.

Headlights.

Headlights and Night Driving. Joseph Tracy. Suggestions and cautions. 1000 w. Automobile—Oct. 1, 1904. No. 65392.

Martini.

The 16-20 h. p. Martini. Illustrated description of one of the cars used by Captain Deady in his recent Alpine tour. 1500 w. Autocar—Oct. 8, 1904. No. 65587 A.

Rebuilding.

Rebuilding an Early Winton. A. Wilson Dods. An account of how the writer rebuilt Winton No. 61. Ills. 1200 w. Automobile—Oct. 1, 1904. No. 65391.

Speed Changing.

The Sturtevant: A Car with Automatic Change-Speed. Illustrated detailed description of a new gasoline automobile with novel features of exceptional interest. 2300 w. Automobile—Oct. 8, 1904. No. 65499.

Speed Indicators.

Speed Indicators for Automobiles. Illustrates and describes new types. 2500 w. Auto Jour—Oct. 15, 1904. Serial. 1st part. No. 65681 A.

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Steam Wagon.

The Pyrodyen Steam Wagon. Illustrated description of a steam wagon to carry a load of 7½ tons. The fuel used is petroleum oil of the cheapest kind. 1000 w. Engr, Lond—Oct. 21, 1904. No. 65843 A.

Steel Specialties.

Automobile Steel Specialties. George E. Walsh. On the amount of steel used for this industry, the quality, tests, &c. 1200 w. Sci Am—Oct. 15, 1904. No. 65544.

HEATING AND COOLING.

Heat Loss.

Some Experiments on Loss of Heat from Iron Pipes. R. W. Leonard. Gives results of experimental investigations. 1000 w. Can Soc of Civ Engrs, Adv. Proof—Oct., 1904. No. 65817 D.

Hot Water.

Heating by Hot Water (Chauffage à Eau Chaude). A. Monteilhet. With especial reference to the Rouquaud system of assisted circulation. 2000 w. Génie Civil—Sept. 24, 1904. No. 65719 D.

Humidification.

The Humidification of Textile Establishments (L'Humidification des Locaux de l'Industrie Textile). Paul Razous. A review of the artificial methods of maintaining the proper hygrometric state of the atmosphere for spinning and weaving operations. 2000 w. Génie Civil—Sept. 17, 1904. No. 65715 D.

Steam Heating.

A New System of Vacuum Return Line Exhaust Steam Circulation. James A. Donnelly. Read before the Modern Science Club, Brooklyn, N. Y. Reviews early patents, describing the Williames thermostatic or automatic system as now installed, and naming the disadvantages of these systems, suggesting remedies and describing new valves that will work well on the Williames system. Ills. 4000 w. Met Work—Oct. 8, 1904. No. 65454.

Ventilation.

The Ventilation of the Hotel Astor, New York. Description, with drawings, of an extensive equipment of fans and blowers for circulating air through the building. 3000 w. Eng Rec—Oct. 8, 1904. No. 65465.

HYDRAULICS.

Intensifiers.

Notes on the Design of Hydraulic Intensifiers. G. E. Flanagan. Illustrated description of a three-phase hydraulic intensifier, explaining also the two-stage, and single-stage apparatus. 700 w. Am Mach—Oct. 20, 1904. No. 65629.

Pelton Wheel.

The Pelton Water Wheel Equipment in the Puget Sound Power Company's Plant. George J. Henry, Jr. An illustrated detailed description. 2500 w. Jour of Elec—Oct., 1904. No. 65506 C.

Pneumatic Pumping.

Air Lift Pumps. W. H. Booth. Gives a brief description of the principle on which the air lift pump works, discussing its advantages and disadvantages. 2200 w. Elec Rev, Lond—Sept. 23, 1904. No. 65444 A.

The Installation of a Pneumatic Pumping Plant. Elmo G. Harris. Discussion of paper by Arthur H. Diamant, Jr. 2000 w. Pro Am Soc of Civ Engrs—Oct., 1904. No. 65824 E.

Pumps.

Motor Driven Pumps. W. H. Wakeman. Illustrates and describes pumps driven by electricity. 900 w. Elec, N. Y. —Oct. 12, 1904. Serial. 1st part. No. 65513.

Turbines.

The Regulation of Hydraulic Turbines (La Régulation des Turbines Hydrauliques). L. Ribourt. An examination of the action of various turbine governors, comparing the centrifugal type with the hydraulic cataract form. 6000 w. 3 plates. Mem Soc Ing Civ de France—July, 1904. No. 65734 G.

Water Wheels.

The Water Wheel. Sidney Russell. An illustrated historical review of the various types, and some of the applications. 8600 w. Trac & Trans—Oct., 1904. No. 65533 E.

INTERNAL COMBUSTION MOTORS.

Alcohol.

Alcohol for Motors. M. C. Krarup. Discusses the causes that have led to the use of alcohol in Europe, and also the merits of alcohol as a fuel, and its importance to engine builders. 2000 w. Am Mach—Vol. 27, No. 41. Serial. 1st part. No. 65540.

Gas Engines.

The Economy of Large Gas Engines. Remarks made by Dr. Edward Hopkinson, as a witness before the Royal Commission on coal supplies, dealing with the economy of fuel which may be anticipated from the use of large gas engines in the place of steam engines for driving dynamos. 2800 w. Mech Engr—Oct. 1, 1904. No. 65519 A.

The Gas Engines of the Société Française de Constructions Mécaniques (Moteurs à Gaz Construits par la Société Française de Constructions Mécaniques). Ch. Dantin. With drawings of engines,

and a photograph of a 1,200 h. p. engine in course of erection. 2000 w. 1 plate. Génie Civil—Oct. 8, 1904. No. 65723 D.

Gas Power.

A Gas Engine Harbor Electric Plant. Illustrated description of interesting features in the plant of the Midland Railway Company at the new harbor in Morecambe Bay for the Isle of Man and Irish traffic. 3300 w. Elec Wld & Engr—Oct. 8, 1904. No. 65495.

Power Gas from Peat (Ueber Torfgas zum Motorbetrieb). E. Hubendick. An account of the successful use of peat for the production of gas for use in gas engines, in Sweden. 1200 w. Oesterr Zeitschr f Berg u Hüttenwesen—Sept. 24, 1904. No. 65759 D.

The Importance of Furnace Gases for Electric Traction (Die Bedeutung des Gichtgases für die Elektrische Traktion). O. Peter. A discussion of the availability of power from blast furnace gases for operating electric traction in the vicinity of iron works. Serial. Part I. 4000 w. Glasers Annalen—Oct. 1, 1904. No. 65751 D.

Gas Producers.

Gas Producers on Shipboard. Bernhard A. Sinn. Describes the suction gas producer, and gives an illustrated description of its installation on shipboard, with report of its operation. 2200 w. Marine Engng—Oct., 1904. No. 65409 C.

Launch Motor.

The Design of a Launch Motor. Edward Butler. Illustrated detailed description of a compound kerosene oil motor. 2700 w. Mech Engr—Sept. 24, 1904. Serial. 1st part. No. 65441 A.

Petroleum Motors.

Oil Engines. Gustave Ey. Read before the Engng. Assn. of N. S. W. An explanation of the Otto cycle, two-stroke cycle, carburetter and vaporizer, and igniters. Ills. 3000 w. Aust Min Stand—Sept. 1, 1904. No. 65439 B.

The Allsop Smokeless Petroleum Engine. Illustrates and describes an engine which uses common petroleum as a source of energy; runs without smoke or smell, and leaves no carbonaceous deposit in the cylinder. 1200 w. Autocar—Oct. 1, 1904. No. 65516 A.

Petrol Motors.

Horse-Power Computation for Petrol Motors. Capt. C. C. Longridge. Three motors are taken and various formulæ are stated and applied to determine which are of practical value. Piston displacement is also discussed, also horse-power charts. 1200 w. Engr, Lond—Oct. 7, 1904. No. 65576 A.

See also Mechanical Engng., Automobiles.

MACHINE WORKS AND FOUNDRIES.

Aligning.

A Handy Tool for Locating and Aligning Shafting and Machinery. William H. Brooks. An illustrated description of the tool and the principle of its operation. 1000 w. Eng Rec—Oct., 1904. No. 65429 C.

Balancing.

Balancing a Valve and Diaphragm. Jas. Clark. Gives the author's solution of the problem of finding the outside diameter of a diaphragm to balance a valve of 1¼ inches diameter of seat, both connected to the same stem, which was ½ inch diameter. 500 w. Am Mach—Vol. 27, No. 43. No. 65810.

Blowers.

Cupola Fan Practice. W. H. Carrier. Read at the A. F. A. Convention, 1904. Gives reliable data relative to the operation of centrifugal blowers for cupola service. 2800 w. Foundry—Oct., 1904. No. 65379.

Fan Blowers for Cupola Work. G. William Sangster. Read at the A. F. A. Convention, 1904. Notes on the principles of fan blowers. 1700 w. Foundry—Oct., 1904. No. 65380.

Brass Castings.

Casting Brass Liners on Propeller Shafting. A. Urquhart. Illustrates and describes the method of casting brass liners on propeller shafting. 800 w. Foundry—Oct., 1904. No. 65381.

Bronze Castings.

Williamsburg Bridge Tablets. Illustrated description of the making of these large tablets. 600 w. Foundry—Oct., 1904. No. 65377.

Case-Hardening.

Notes on Cementation. Georges Charpy. A report of experimental investigations and the results obtained. 2200 w. Ir & St Mag—Oct., 1904. No. 65612 D.

Castings.

Steel Castings. W. A. Herron. Briefly describes the several processes in use for making cast steel, the cleaning, inspection, &c. Discussion. 10000 w. Pro Ry Club of Pittsburg—Oct. 18, 1904. No. 65820 C.

Chilled Castings.

Bell Cranks and Small Chilled Castings. C. Neil. Illustrates and describes methods of molding. 700 w. Foundry—Oct., 1904. No. 65385.

Costs.

Percentage Method of Determining Production Costs. Harrington Emerson. Describes a percentage method of working from a basis of elementary labor and material costs. 1700 w. Foundry—Oct., 1904. No. 65383.

We supply copies of these articles. See page 475.

Cupolas.

Cupola Practice. Harry Willis. Describes practice in one of the best foundries in New Zealand. 1200 w. Foundry—Oct., 1904. No. 65382.

Electric Power.

Description of the Electrical Equipment of an Engine Works and Shipyard, with Notes Thereon. H. O. Wraith. Read before the Leeds Local Sec. of the Inst. of Elec. Engrs. Discusses the question of converting large works of this type to electric driving. 4500 w. Elec Engr, Lond—Oct. 14, 1904. Serial. 1st part. No. 65685 A.

Factory.

Organization of the Remington Typewriter Factory at Ilion, N. Y. John Calder. An explanation of the organization of a factory which can employ 2,000 people. 2000 w. Ir Trd Rev—Oct. 6, 1904. No. 65486.

Foundry.

The New Foundry of the Hilles & Jones Company. Illustrated description of a new foundry at Wilmington, Del. The walls are of concrete to a height of 14 ft., and are of glass set in iron framework the remainder of the distance to the roof. 3000 w. Ir Age—Oct. 13, 1904. No. 65537.

Gages.

The Grinding of Thread Gages. J. R. Gordon. Describes the different operations the writer has used in making these tools. 1200 w. Mach, N. Y.—Oct., 1904. No. 65430 C.

Grinding.

Some New Cutter and Tool-Grinding Machinery. Charles S. Gingrich. Illustrated detailed descriptions of examples from American practice. 4000 w. Cassier's Mag—Oct., 1904. No. 65349 B.

Hardening.

Experiences and observations in Hardening Tools. From the *Zeitschrift fuer Werkzeugmaschinen und Werkzeuge.* Gives results obtained from a series of experiments to find the best hardening temperature for different kinds of steel. 2000 w. Am Mach—Sept. 29, 1904. No. 65360.

Inspection.

The Practical Inspector. E. N. Percy. Suggestions on inspection of materials. 2000 w. Mach, N. Y.—Oct., 1904. No. 65428 C.

Locomotive Works.

New Locomotive Works in Canada. Illustrated description of the recently built works of the Locomotive and Machine Company of Montreal, Limited. 900 w. Engr, Lond—Sept. 30, 1904. No. 65529 A.

Machine Shop.

The New Cail Shops at Denain (Les Nouvelles Usines Cail à Denain). Ch. Dantin. A fully illustrated account of the new shops of the Société Français de Constructions Mécaniques, successors to the old firm of Cail & Co. Two articles, two plates. 5000 w. Génie Civil—Sept. 24, Oct. 1, 1904. No. 65718 each D.

Melting.

Cost of Melting in an Oil Furnace. James F. Webb. Claims that there is a saving in melting brass in the Rotary furnace. 700 w. Foundry—Oct., 1904. No. 65376.

Molding.

Molding Machine Practice. F. W. Hall. Illustrated description of the arranging of a ratchet wheel on a molding machine. 1800 w. Foundry—Oct., 1904. No. 65384.

Oil Fuel.

Economy and Advantage of Oil Fuel for Forging. Extract from a paper by S. Uren, to the Nat. R. R. Master Blacksmiths' Ass'n. Gives a comparison of the cost of coal and oil in the smith shop. 1500 w. Ry & Engng Rev—Oct. 1, 1904. No. 65415.

Planers.

Important Improvements in Planer Design. Illustrates and describes some recent planers which show that some very radical changes in design have been made with surprising results. 2000 w. Am Engr & R R Jour—Oct., 1904. No. 65414 C.

Rolling Mill.

The Friedenshütte Rolling Mill (Trägerwalzwerk der Friedenshütte). Fr. Frölich. Illustrated description of recent mills for rolling beams and structural shapes, at the Friendenshütte, in Upper Silesia. 2000 w. Zeitschr d Ver Deutscher Ing—Sept. 17, 1904. No. 65700 D.

Sand Blast.

A New Sand-Blast Apparatus. Francis Sticker. Illustrated detailed description of the apparatus. 2000 w. Am Mach—Vol. 27, No. 41. No. 65539.

Screws.

The Geometry of the Square-Thread Screw. Ferdinand Peam. Indicates how screws and nuts of low helix angle may be made a commercially perfect fit. Ills. 3000 w. Am Mach—Vol. 27, No. 43. No. 05809.

Screw Threads.

The Unification of Screw Threads (Unification des Filetages). A discussion of the standardization of metric screw threads for small screws, less than

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six millimetres in diameter. 6000 w. Bull Soc d'Encour—Sept., 1904. No. 65729 G.

Shop Methods.

A Development of Recent Machine Shop Processes. W. M. Barr. A review of methods of producing interchangeable work in the general shop, with especial reference to marine-engine work. 3000 w. Engineering Magazine—Nov., 1904. No. 65779 B.

Shop Records.

Report of the Joint Committee of the American Railway Mechanical & Electrical Association and the Street Railway Accountants' Association of America on Blanks for Shop Records and Accounts. 3300 w. St Ry Jour—Oct. 15, 1904. No. 65603 C.

Shrinkage.

Shrinkage Troubles and Methods of "Feeding." Thomas D. West. Read before the New England Found. Assn. Discusses the different methods that may be employed to prevent shrinkage. 2500 w. Ir Trd Rev—Oct. 20, 1904. No. 65646.

Stores.

Stores Arrangement as a Factor in Shop Management. John Ashford. The second article discusses the practical details of execution of a stores system; with illustrations from various important shops. 3000 w. Engineering Magazine—Nov., 1904. No. 65774 B.

Tubes.

Weldless Tubing (Tubes sans Soudure). L. Joubert. A discussion of the methods of making seamless tubing of iron or steel, including the practice in France, England, Sweden, and Germany. 7500 w. 1 Plate. Mem Soc Ing Civ de France—July, 1904. No. 65733 G.

Type-Founding.

Early Methods of Type-Founding. A brief history of the evolution of the type-mould as brought out by the researches of J. Eliot Hodgkin. Ills. 4600 w. Engng—Oct. 14, 1904. No. 65691 A.

Westinghouse.

The Pittsburg Works of the Westinghouse Company. John R. Hewett. Illustrated detailed description of the large works at East Pittsburg, Pennsylvania. 10000 w. Trac & Trans—Oct., 1904. No. 65532 E.

Works Administration.

Obsolete Methods and Current Practice in Works Administration. Egbert P. Watson. A review of past practice, comparing it with modern systems. 3000 w. Engineering Magazine—Nov., 1904. No. 65776 B.

MATERIALS OF CONSTRUCTION.

Cast Iron.

Some Phenomena in the Shrinkage of Cast Iron. Thomas D. West. A study of the shrinkage question presenting facts of interest and suggesting ideas for valuable research. 1000 w. Ir & St Mag—Oct., 1904. No. 65613 D.

Lubricants.

Mineral Lubricating Oils. J. N. Bruck. Gives some historical facts relating to petroleum; considers its refining, gravity and fire tests, and concludes that the mineral oil which has the greatest adhesion to metallic surfaces, and the least cohesion between its own particles, is the best lubricant. 3000 w. Aust Min Stand—Sept. 1, 1904. No. 65440 B.

Manganese.

Use of Manganese in the Cupola or the Ladle. N. W. Shed. An account of experiments made to determine whether it makes any difference in the castings whether the manganese is added to the cupola or to the ladle. Gives results. 1100 w. Foundry—Oct., 1904. No. 65378.

Metals.

Surface Flow and the Hard and Soft State in Metals. Reviews the researches of Mr. G. T. Beilby, of Glasgow, on surface flow and the hard and soft conditions of metals, which are of considerable practical importance. 3000 w. Engng—Oct. 7, 1904. No. 65573 A.

Protective Coatings.

Sherardizing. Illustrates and describes a new process, invented by Sherard Cowper-Coles, for protecting iron and steel from corrosion. 2200 w. Ir Age—Oct. 20, 1904. No. 65633.

Steels.

Investigations upon Steels Containing Titanium and Tin (Recherches sur les Aciers au Titane et à l'Etain). Léon Guillet. Giving results of mechanical and metallographical tests of various carbon content, alloyed with titanium and with tin. 1800 w. Génie Civil—Sept. 17, 1904. No. 65716 D.

Properties, Classification, and Utilization of Special Ternary Steels (Propriétés, Classification et Utilisation des Aciers Spéciaux Ternaires). L. Guillet. A discussion of alloy steels composed of iron, carbon, and one other metal, stating briefly the qualities of steels containing nickel, manganese, chromium, tungsten, molybdenum, vanadium, silicium, titanium, aluminum, cobalt, and tin. 12000 w. 1 plate. Mem Soc Ing Civ de France—July, 1904. No. 65735 G.

The Constitution and Properties of Tungsten Steels (Constitution et Proprié-

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tés des Aciers au Tungstène). Léon Guillet. Results of chemical and metallographical investigations of steels of various contents of carbon and tungsten, showing the conditions existing in tempering and air hardening. 1000 w. Comptes Rendus—Sept. 26, 1904. No. 65749 B.

The Properties and Constitution of Molybdenum Steels (Propriétés et Constitution des Aciers au Molybdène). Léon Guillet. Experiments upon steels with various proportions of molybdenum, showing the strength, hardening, and tempering properties. 800 w. Comptes Rendus—Oct. 3, 1904. No. 65750 B.

Structural Steel.

The Fracture of Structural Steel Under Alternating Stresses. Prof. John O. Arnold. Read before the British Assn. Gives facts learned by experimental investigations covering two years. Ills. 1300 w. Mech Engr—Sept. 24, 1904. No. 65442 A.

Tempering.

Notes on the Tempering of Steel (Etudes sur la Trempe de l'Acier). Henry le Chatelier. A study of the effect of temperature, contact, composition, dimensions and manipulation upon the tempering of steel. 8000 w. Rev de Metallurgie, Bull Soc d'Encour—Sept., 1904. No. 65730 G.

Testing.

A New Method of Testing Metals (Une Nouvelle Méthode d'Essais Mécaniques des Métaux). M. Guillery. The hardness is determined by Brinell's method, the elastic limit by the change in the appearance of a polished surface, and the brittleness by the fracture of a nicked bar in a special apparatus. 5000 w. Rev de Metallurgie, Bull Soc d'Encour—Aug., 1904. No. 65755 G.

Tool Steel.

The Development and Use of High-Speed Tool Steel. J. M. Gledhill. On the development and thermal treatment of high-speed steel, referring to its practical use and some of the most recent work done with it. Ills. 12000 w. Iron & Steel Inst—Oct., 1904. No. 65803 D.

The Practical Handling of High Speed Steel. Gives general principles applicable to most of the rapid cutting steels. 1500 w. Ir Age—Oct. 6, 1904. No. 65468.

MEASUREMENT.

Barometer.

The Construction of an Indicating or Recording Tin Plate Aneroid Barometer. N. Monroe Hopkins. Illustrates and describes the construction of a very successful aneroid barometer out of simple tin plates. 2700 w. Sci Am Sup—Oct. 1, 1904. No. 65389.

Centrifugal Force.

Radial Stresses Due to Centrifugal Force in Revolving Bodies. A. M. Levin. A mathematical study to determine to what extent the material will be strained, and what form would ensure the greatest strength. 2500 w. Am Mach—Vol. 27, No. 42. No. 65628.

Inertia.

Determination of the Moment of Inertia of Parallel Forces in One Plane (Die Bestimmung des Trägheitsmomentes Paralleler in derselben Ebene Liegender Kräfte). Nikolaus von Szüts. Showing the application of the graphical method to the solution of the problem. 2000 w. Zeitschr d Oesterr Ing u Arch Ver—Sept. 23, 1904. No. 65726 D.

Metric System.

The Metric System in Mechanical and Electrical Engineering. Read before the Rugby Engng. Soc. I. Introductory Statement for the Metric System. Ernest R. Briggs. II. Reply to the Introductory Statement. R. C. Jackson. Also editorial. 5000 w. Elec Engr, Lond—Oct. 14, 1904. No. 65686 A.

Stresses.

Stresses in Thin Cylinders Subjected to Internal Pressure. A. T. Weston. Gives a brief description of a method of dealing with this problem in its most general form, and points out the direction in which its practical applications will lie. 1800 w. Engr, Lond—Sept. 23, 1904. No. 65452 A.

POWER AND TRANSMISSION.

Conveying.

Coal-Conveying Plant at a Manchester Power Station. Illustrated description of the coal and ash-handling arrangements. 1000 w. Engr, Lond—Oct. 7, 1904. No. 65579 A.

Tepherage. C. J. Messer. An illustrated article on the value of electric propulsion applied to aerial transportation of materials, describing several interesting installations. 4500 w. Jour Fr Inst—Oct., 1904. No. 65436 D.

Elevators.

Hydraulic Plunger Elevators. William Baxter, Jr. An illustrated detailed description of this type and its working. 3000 w. Engr, U S A—Oct. 15, 1904. No. 65606 C.

Modern Elevator Types and Elevator Practice. H. S. Knowlton. Describing especially the later electric and hydraulic systems. 3500 w. Engineering Magazine—Nov., 1904. No. 65778 B.

Mechanical Handling.

Modern Appliances for the Economical Handling of Material. Henry E. P. Cot-

trell. Describes and illustrates modern grabs, excavators, &c., and the work they accomplish. 5700 w. Engng Rev—Oct., 1904. No. 65569 B.

Special Transport Appliances in Modern Machine Works (Spezial Konstruktionen Moderner Transportmittel für Hüttenwerke). Illustrating furnace-charging machines, traveling cranes, and special appliances for handling ingots, etc. Three articles. 8000 w. Stahl u Eisen—Sept. 15, Oct. 1, 15, 1904. No. 65769 each D.

Power.

Gas, Oil and Steam for Power. Michael Longridge. Lecture delivered before the British Assn. of Mgrs. of Textile Works. Restricts the paper to the consideration of steam, gas, and oil engines as heat engines. 3500 w. Engr, Lond—Oct. 14, 1904. Serial. 1st part. No. 65800 A.

Speed Changes.

Calculating Cone Steps and Back-Gearing Ratios by the Slide Rule. W. Owen. Deals with the application of the slide rule to calculations necessary in designing machine tools. 1000 w. Am Mach—Oct. 20, 1904. No. 65631.

STEAM ENGINEERING.

Boiler-Feed.

Air in Relation to Boiler-Feeds. Jas. Alex. Smith. Read before the Victorian Inst. of Engrs., at Melbourne. A record of data derived from original observations referring to the absorption by comparatively pure water of atmospheric components, and the effects in relation to some engineering problems. 2500 w. Engng—Oct. 7, 1904. No. 65575 A.

The Use of Soda Ash in Locomotive Tanks. S. K. Dickerson. Discusses points of importance in using soda ash, and claims that when properly used it increases the life of the flues, gives less trouble from leaky flues, stay bolts, seams, &c. Ills. 1700 w. Pro Cent Ry Club—Sept., 1904. No. 65621 C.

Boilers.

The Care of Locomotive Boilers. M. E. Wells. Discussion of this subject from the conclusion that it is inequality of temperature which causes most boiler troubles. 1200 w. Ry Age—Oct. 21, 1904. Serial. 1st part. No. 65660.

The Dürr Water-Tube Marine Boiler (Wasserrohr Schiffskessel, System Dürr). The design includes inclined water tubes, with interior circulating tubes, and overhead steam drum. 1800 w. Glasers Annalen—Oct. 1, 1904. No. 65753 D.

Boiler Tests.

Evaporative Tests of Lancashire Boilers. William D. Hamilton. Describes tests carried out for the purpose of demonstrating a guarantee that each boiler would evaporate 10,000 lbs. of water per hour from a feed-water temperature of 240 deg. Fah. with rough small steam coal after it had passed through a mesh ¾ in. diameter. 3300 w. Prac Engr—Oct. 14, 1904. No. 65684 A.

Chimneys.

Chimney Action. W. H. Booth. Discusses the efficiency of chimneys, their working, draught, &c. 3000 w. Elec Rev, Lond—Oct. 14, 1904. No. 65688 A.

Condensation.

Condensing Plant. W. H. Booth. Illustrates and describes types of British condensers and accessories. 5000 w. Cassier's Mag—Oct., 1904. Serial. 1st part. No. 65348 B.

Draft.

Mechanical Draft for Boilers. Abstract of a paper read by W. Yates, of Liverpool, before the Inst. of Heat. and Vent. Engrs. Remarks on the combustion of fuel, and the best means of producing the requisite draft, discussing forms of mechanical draught. Ills. 2000 w. Prac Engr—Sept. 30, 1904. Serial. 1st part. No. 65518 A.

Engines.

Corliss Engine Design. L. L. Willard. The first of a series of illustrated articles aiming to show how these engines are being built, and how to proportion the parts to secure the best results at a reasonable cost. 1200 w. Engr, U S A—Oct. 1, 1904. Serial. 1st part. No. 65425 C.

Design of High-Speed Enclosed Steam Engines. An illustrated series of articles dealing with some of the main points to be considered in the design of the details, and mentioning some of the difficulties. Shows the development of the high-speed engine as used for electric lighting and traction. 2800 w. Engr, Lond—Oct. 21, 1904. Serial. 1st part. No. 65841 A.

Some Old Engines in Cornwall. Illustrates and describes engines of ancient design. 1000 w. Engr, Lond—Oct. 14, 1904. No. 65697 A.

Variety in Steam Engines. Remarks on the great variety of engines for different uses with a review of the advantages and disadvantages of horizontal and vertical reciprocating steam engines and horizontal and vertical steam turbines. 2000 w. Mech Engr—Oct. 8, 1904. Serial. 1st part. No. 65586 A.

Engine Testing.

The Systematic and Accurate Testing

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of Steam Engines. H. R. Sankey & C. H. Wingfield. Describing the very complete laboratory and methods of the Victoria Works at Rugby, and a review of the development of testing methods and appliances. 5000 w. Engineering Magazine—Nov., 1904. No. 65777 B.

Exhaust Steam.

The Utilization of Exhaust Steam, from Engines Acting Intermittently, by Means of Regenerative Steam Accumulators and of Low-Pressure Turbines on the Rateau System. Emile Demenge. An illustrated description of this system and the applications already in operation. 5600 w. Iron & Steel Inst—Oct., 1904. No. 65805 D.

Fuel Economy.

Fuel Economy in Central Generating Stations. John B. C. Kershaw. Reviews and discusses some recently published papers and articles on this subject, calling attention to points of importance. Ills. 4000 w. Elec Rev, N Y—Oct. 15, 1904. No. 65601.

Liquid Fuel.

Types of Oil Burners. Gives suggestions of the Naval Liquid Fuel Board. Ills. 1800 w. Ir Age—Sept. 29, 1904. No. 65364.

Piping.

Live Steam Piping: What Constitutes Good Design and What Should Be Avoided. Charles K. Stearns. Gives a few of the principles underlying good design, discussing details. 2000 w. St Ry Rev—Oct. 14, 1904 (Daily Ed.). No. 65597 C.

Power Plant.

The Power Plant of the Columbian Cordage Company. Illustrates and describes a steam power plant at Auburn, N. Y., interesting because of its remarkably rapid construction in view of the magnitude of the establishment. 2000 w. Eng Rec—Oct. 15, 1904. No. 65562.

Separators.

Devices for the Purification of Steam and Its Water of Condensation (Appareils pour l'Epuration de la Vapeur et de son Eau de Condensation). An exhaustive review of the various types of separators for removing water from live steam and oil from the exhaust. Serial. Part I. 4500 w. Revue de Mècanique—Sept., 1904. No. 65732 E + F.

Steam Turbines.

American Steam Turbines (Amerikanische Dampfturbinen). Clarence Feldmann. An account of the De Laval, Westinghouse-Parsons, and Curtis steam turbines, as studied by the writer during a visit to the United States. Two articles. 5000 w. Zeitschr d Ver Deutscher Ing—Sept. 24, Oct. 1, 1904. No. 65705 each D.

Improvements in Fractional Supply Steam Turbines. Algidius Elling. Discusses the two types of turbines, those with parallel (or converging) nozzles, and those with diverging nozzles in the guide apparatus, showing the loss in working; and describes an innovation for diminishing the losses of efficiency. 2700 w. Prac Engr—Oct. 14, 1904. Serial. 1st part. No. 65682 A.

On the Steam Turbine in Germany. Dr. Alfred Gradenwitz. An illustrated short account of the status of the turbine question in Germany. The present article describes the Zoelly turbine. 1300 w. Prac Engr—Oct. 21, 1904. Serial. 1st part. No. 65848 A.

Steam Turbine Construction. O. Lasche. Illustrated description of experimental results obtained in the shops of the Union Elektricitäts-Gesellschaft. 1500 w. Power—Oct., 1904. No. 65418 C.

Steam Turbine Power Plants. J. R. Bibbins. Notes on their equipment and operation; discussing the economics of high vacua and superheat, condensers, cost, etc. Ills. 5500 w. St Ry Rev—Oct. 14, 1904. (Daily Ed.). No. 65596 C.

Steam Turbines. Richard H. Rice. Read before the convention of the Am. St. Ry. Assn. A discussion of types of the Curtis turbines, and the special problems that require solution. Gives a list of Curtis turbines of small sizes from 1½ to 300 kw., no gearing being used in the corresponding turbo-generators. 2300 w. Eng Rec—Oct. 15, 1904. No. 65563.

The DeLaval Steam Turbine Company. An illustrated description of their works and product, with sketch of Carl Gustaf P. De Laval, the Swedish inventor. 3500 w. Mach, N Y—Oct., 1904. No. 65427 C.

The Hamilton-Holzwarth Steam Turbine. Illustrated detailed description of a new steam turbine on exhibition at St. Louis. 4200 w. Ir Age—Sept. 29, 1904. No. 65362.

The Riedler-Stumpf Turbine and Its Applications. Abridged translation of a paper read by Dr. A. Riedler before the Oesterreichischen Ingenieur und Architekten Vereines. Illustrated description of his own turbine. 2500 w. Power—Oct., 1904. No. 65419 C.

Thermodynamic Diagrams for Steam-Turbine Computations (Thermodynamische Rechentafel für Dampfturbinen). Dr. R. Proell. Discussing straight-line diagrams for abridging the labor of computations, both for saturated and superheated steam. 2000 w. Zeitschr d Ver Deutscher Ing—Sept. 17, 1904. No. 65703 D.

See Also Electrical Engineering, Generating Stations.

See Also Marine Engineering.

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Tube Cleaners.

Concerning Tube Cleaners. An illustrated article discussing the damage done by power cleaners for boiler tubes. 2800 w. Locomotive—Oct., 1904. No. 65593.

Valve Gears.

Adjustment of Corliss Valve Gears. Ralph D. Van Valkenburgh. An illustrated article considering the essential conditions for valve gears and how to set them for best performance. 3000 w. Ice & Refrig—Oct., 1904. Serial. 1st part. No. 65401 C.

MISCELLANY.

Aeronautics.

A Device for the Application of Intermittent Efforts to the Propulsion of Masses in Elastic Media (Konstruktion zur Ermöglichung der Intermittierenden Kraftausnützung bei Fortbewegung von Massen in Elastischen Mitteln). Viktor Hänisch. Describing a mechanical movement for reproducing wing motion in flight. 4000 w. 1 plate. Zeitschr d Oesterr Ing u Arch Ver—Sept. 16, 1904. No. 65725 D.

Mechanical Flight. J. Emery Harriman, Jr. Considers, mainly, flying machines heavier than the air displaced by them, referring to the machines of Lilienthal, Chanute, the Wright brothers, Harriman, and others. Ills. 4000 w. Jour Assn of Engng Socs—Aug., 1904. No. 65515 C.

The 1904 Campaign of the Lebaudy Balloon (La Campagne de 1904 du Ballon Lebaudy). Col. G. Espitallier. With views of the latest Lebaudy dirigible balloon, and an account of the experimental trips of the year. 2000 w. Génie Civil—Oct. 1, 1904. No. 65721 D.

Guns.

Machine Guns Up to Date. Lieut.-Colonel E. Rogers. Gives an account of the use of these guns in various battles. General discussion follows. 10000 w. Jour Roy United Service Inst—Sept., 1904. No. 65358 E.

MINING AND METALLURGY

COAL AND COKE.

Anthracite.

The Virginia Anthracite Coal Field. L. L. Randolph. A descriptive historical account of this field, which was first discovered fifty years ago. Map and sections. 2000 w. Eng News—Oct. 20, 1904. No. 65636.

Briquets.

The Fuel Briquetting Industry. John Fulton. Considers the materials of which briquets are made, binders, fuel value, shapes of briquets, and processes and machinery used. Ills. 4600 w. Mines & Min—Oct., 1904. Serial. 1st part. No. 65394 C.

British Columbia.

Coal in British Columbia. W. A. Harkins. Outlines the results accomplished at Coleman in less than a year, in these bituminous coal lands. 1700 w. Min & Sci Pr—Oct. 15, 1904. No. 65676.

Graham Island Coal. William Blakemore. This island is the most northerly of the Queen Charlotte group, on the northwest coast of British Columbia. Gives information of these deposits and their value. 1200 w. Eng & Min Jour—Oct. 20, 1904. No. 65649.

Coal Handling.

The Coal Handling Plant at the Gerhard Mine at Louisenthal on the Saar (Die Einrichtungen zur Verladung von Kohlen auf der Grube Gerhard bei Louisenthal a. d. Saar). H. Althans. With plans of the buildings and tracks, and illustrations of the conveyors, cranes and buckets for delivering the coal into barges by the wharf. 3000 w. 5 plates. Glückauf—Sept. 17, 1904. No. 65760 D.

Coal Testing.

Coal-Testing Plant of the U. S. Geological Survey at St. Louis. Kurt Toensfeldt. An illustrated description of this plant and the methods of testing. 1800 w. Engr,. U S A—Oct. 15, 1904. No 65607 C.

Coal Washing.

A Modern Method of Coal Washing. C. A. Meissner. Abstract from the *Journal* of the Min. Soc. of Nova Scotia. Describes the washing at the plant of the Dominion Iron and Steel Company. 1200 w. Eng & Min Jour—Oct. 13, 1904. No. 65552.

Coal Working.

On the Methods of Working Coal in Saxony and Austria. Illustrates and describes the methods used in these collieries, and describes the working of lignite in northwest Bohemia. 2500 w. Ir & Coal Trds Rev—Oct. 7, 1904. No. 65581 A.

Coke.

Notes on the Manufacture of Coke. John Bell. Abstract of a paper read be-

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fore the British Soc. of Min. Students. Deals only with ovens of the beehive type. Ills. 2500 w. Ir & Coal Trd Rev—Oct. 7, 1904. No. 65580 A.

Preparation of Alabama Coal for Coke Making. L. O. Gabany. Abstract of a paper read before the Engng Assn. of the South. Describes the coal and the treatment needed. 1300 w. Eng & Min Jour—Oct. 27, 1904. No. 65829.

Colliery.

The Henry Colliery of the Davis Coal and Coke Company. J. F. Healy. An illustrated description of the plant and the mechanical equipment. 2700 w. Mines & Min—Oct., 1904. No. 65398 C.

Gas Coal.

The Determination of the Value of Gas Coals (Die Wertbestimmung der Gaskohlen). Dr. Bertelsmann. A comparison of various English and German coals with regards to their adaptability for the production of illuminating gas. 2000 w. Glückauf—Sept. 24, 1904. No. 65762 D.

New Mexico.

The Hagan Coal Field. Charles R. Keyes. Brief illustrated description of a newly opened coal-field in New Mexico, showing some features of the cretaceous coals of the Southwest. 800 w. Eng & Min Jour—Oct. 27, 1904. No. 65831.

New Mine.

A Monongahela River Mine. Brief description of the opening of a new coal mine. 1200 w. Eng & Min Jour—Oct. 6, 1904. No. 65487.

COPPER.

Arizona.

The Warren District, Arizona. An illustrated article describing recent developments which have made Bisbee one of the largest copper mining camps in the United States, and giving information in regard to the deposits. 2500 w. Eng & Min Jour—Oct. 6, 1904. No. 65488.

Chemistry.

The Chemistry and Metallurgy of Copper. Charles D. Palmer. The first of a series of papers. The present number considers the meaning of the word metal, and its two lines of properties, the physical and the chemical. 4000 w. Eng & Min Jour—Oct. 20, 1904. Serial. 1st part. No. 65647.

Lake Superior.

Copper Mines of Lake Superior. T. A. Rickard. The first of a series of articles giving an illustrated detailed description of the copper mining region of the Keweenaw peninsula in Northern Michigan. 2000 w. Eng & Min Jour—Oct. 13, 1904. No. 65548.

Refining.

Some Notes on the Electrolytic Refining of Copper at Anaconda, Montana. E. C. Sickles. Description and general information of one of the most economical and complete electrolytic plants. Ills. 1400 w. Sib Jour of Engng—Oct., 1904. No. 65670 C.

Smelting.

Ore-Roasting at the Tyree Copper Company's Smelter on Vancouver Island. E. Jacobs. Describes the manner of dealing with the bulk of the ore before it reaches the furnace, particularly the arrangement, appointments and operating methods of the ore-roasting yard. Ills. 1800 w. B C Min Rec—Oct., 1904. No. 65546 B.

United States.

Occurrence and Distribution of Copper in the United States. Walter Harvey Weed. An illustrated article giving information in regard to the location, value, and production of the deposits. Maps. 2800 w. Min Mag—Sept., 1904. No. 65353 C.

Vancouver.

Copper Deposits of Mt. Sicker, Vancouver. Robert Musgrave. Describes the formation and deposits. The ore is chalcopyrite, associated with pyrite, blende and galena, in a gangue consisting mainly of barite, with some quartz and calcite. 1700 w. Eng & Min Jour—Oct. 27, 1904. No. 65832.

GOLD AND SILVER.

Amalgamation.

Milling Practice at the Hidden Fortune Plant, with Special Reference to Amalgamating in Cyanide Solution. Jesse Simmons. Describes this wet crushing cyanide mill, especially the process of amalgamating in a solution of cyanide of potassium. 2000 w. Min Rept—Oct. 20, 1904. No. 65673.

Assaying.

The Assay Weight and Its Relation to the Balance of Precision. A. Whitby. On the difficulty of obtaining weights of sufficient accuracy for the requirements of the more sensitive balance now used. General discussion. 5500 w. Jour Chem Met & Min Soc of S Africa—Aug., 1904. No. 65588 E.

Brazil.

Gold Mines of Minas, Brazil. Martin Schwerin. Points of interest in regard to the gold mines in the State of Minas Geraes. 2000 w. Eng & Min Jour—Oct. 6, 1904. No. 65489.

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Chlorination.

Chlorination in Colorado. William E. Greenawalt. Describes the methods employed, the machinery used and the results. Ills. 3000 w. Eng & Min Jour—Oct. 27, 1904. No. 65830.

The Portland Mill. F. A. Thomson and S. L. Goodale. An illustrated description of the chlorination plant of the Portland Gold Mining Co., at Colorado Springs, Colo. 4600 w. Mines & Min—Oct., 1904. No. 65393 C.

Crushing in Cyanide Solution as Carried on in the Black Hills, S. D. C. H. Fulton. A description of the process. 1500 w. Min & Sci Pr—Sept. 24, 1904. Serial. 1st part. No. 65420.

Deposition.

Gold Deposition by Drainage. William Bradford. An illustrated article giving briefly the writer's views on gold deposit. 500 w. Eng & Min Jour—Oct. 6, 1904. No. 65491.

Milling.

Notes on Mill Construction, Milling and Amalgamation. I. Roskelly. Reply to the discussion of the writer's paper on this subject. 4000 w. Jour Chem Met & Min Soc of S Africa—Aug., 1904. No. 65590 E.

Nevada.

Observations on Tonopah and Goldfield. S. C. Wiel. An illustrated article describing the free gold deposits of Goldfield and the silver deposits of Tonopah, and the methods of mining. 1700 w. Min & Sci Pr—Oct. 8, 1904. No. 65602.

New Goch.

Visit to the New Goch Mines, Ltd. Explanatory remarks by H. S. Denny, on the occasion of a visit to this South African mine to inspect the new tube-mill installation and the treatment of vanner concentrates. 3000 w. Jour Chem, Met & Min Soc of S Africa—Aug., 1904. No. 65591 E.

Nova Scotia.

Stamp Milling Practice in Nova Scotia. Mr. R. O'Shaughnessy. Describes the practice in wet crushing stamp mills. 1300 w. Min & Sci Pr—Oct. 15, 1904. Serial. 1st part. No. 65677.

Ore Treatment.

Ore Treatment at the Ivanhoe Mine, Kalgoorlie. H. J. Brooke. The plant embraces all the successful methods at present in vogue at Kalgoorlie. Descriptive. 1300 w. Eng & Min Jour—Oct. 20, 1904. No. 65651.

Pulp Distribution.

Pulp Distributor for Stamp Batteries. J. L. Buskett. Description and drawings of a pulp distributor which allows of the continuous dropping of the stamps while dressing the plates. 1000 w. Min Rept—Oct. 20, 1904. No. 65674.

Slimes.

Improvements in Slimes Treatment. M. Torrente. Describes a method which refers to the settlement and separation of the slimes from their solutions, and states other advantages derived. 2200 w. Jour Chem, Met & Min Soc of S Africa—Aug., 1904. No. 65589 E.

Supply.

The Future Supply of Gold. From the London *Economist*. Considers that the study of new mines is not keeping pace with the exhaustion of those now being worked. Gives a brief survey of the world's mines. 2400 w. Ir Age—Oct. 6, 1904. No. 65469.

Victoria.

Deep Alluvial Mining in Victoria. F. Danvers Power. Describes the deep leads and the systems of mining. Ills. 2000 w. Eng & Min Jour—Sept. 29, 1904. No. 65403.

IRON AND STEEL.

Analysis.

Comparisons of Methods for the Determination of Carbon and Phosphorus in Steel. Baron H. Jüptner von Jonstorff, Andrew A. Blair, Gunnar Diltner, and J. E. Stead. Remarks by each member of this committee on the methods, with a summary of results. Ills. 15400 w. Iron & Steel Inst—Oct., 1904. No. 65807 D.

Blast Furnaces.

Modern Blast Furnace Construction. I. G. Bayley. A list of requirements from the drawing-office point of view. 6000 w. Ir Age—Sept. 29, 1904. No. 65365.

Canada.

Iron and Steel for Western Canada. William Blakemore. Discussing the possibility of establishing a steel-making industry in British Columbia which would serve the West with cheaper iron and steel and yet realize a profit. 1800 w. Eng & Min Jour—Oct. 13, 1904. No. 65549.

Carbon.

The Determination of Carbon. James A. Aupperle. With special reference to the stability of carbon compounds in steel. 2200 w. Ir Age—Oct. 6, 1904. No. 65470.

Constituents.

The Influence of Carbon, Silicon, Manganese, Sulphur, and Phosphorus Upon the Formation of Temper Carbon in Iron (Der Einfluss von Kohlenstoff, Silizium, Mangan, Schwefel, und Phosphor auf die Bildung der Temperkohle in Eisen). F. Wirst and P. Schlosser. Data and results of tests showing the influence of the various constituents. 2000 w. Stahl u Eisen—Oct. 1, 1904. No. 65771 D.

We supply copies of these articles. See page 475.

Dry-Air Blast.

The Application of Dry-Air Blast to the Manufacture of Iron. James Gayley. An account of the application of the dry-air blast at the Isabella Furnaces of the Carnegie Steel Co., at Etna, Pa., and the economies resulting. Ills. 5400 w. Iron & Steel Inst—Oct., 1904. No. 65801 D.

Furnace Lifts.

Inclined Cable Lifts for Blast Furnaces (Gichtseilbahnen). Rudolph Brennecke. Illustrating and describing a variety of inclined converging devices for delivering the charge to blast furnaces. 2500 w. 2 plates. Stahl u Eisen—Oct. 1, 1904. No. 65770 D.

Lake Superior.

Investigations on the Lake Superior Iron Ore Deposits. U. S. Grant. Gives points of interest concerning the results of the survey of these iron districts. Ills. 3200 w. Min Mag—Sept., 1904. No. 65352 C.

Through the Lake Superior Iron and Copper Mines with the American Institute of Mining Engineers. A brief account of the trip, the sail through the lakes, the Duluth meetings, etc., in the present number. 2200 w. Eng News—Sept. 29, 1904. Serial. 1st part. No. 65371.

New Mexico.

Iron Deposits of the Chupadera Mesa. Charles R. Keyes. Describes the geological conditions under which these deposits were formed, and the conditions which have exposed them to view. 900 w. Eng & Min Jour—Oct. 20, 1904. No. 65650.

Open-Hearth.

Acid Open-Hearth Manipulation. Andrew McWilliam and William H. Hatfield. Investigations made by the writers, showing the chemical composition of the slag, particularly with regard to its acidity, is the factor which determines whether the percentage of silicon in the molten steel shall increase or decrease. 1700 w. Iron & Steel Inst—Oct., 1904. No. 65806 D.

The Influence of Carbon, Phosphorus, Manganese and Sulphur on the Tensile Strength of Open-Hearth Steel. H. H. Campbell. Gives an account of investigations made at the works of the Pennsylvania Steel Co., Steelton, Pa. 10000 w. Iron & Steel Inst—Oct., 1904. No. 65804 D.

Pig-Iron.

Pig-Iron in Its Commercial Aspects. F. M. Thomas. Abstract of a lecture delivered before the Birmingham (Eng.) Metallurgical Society. Considers methods of casting, commercial uses, grading, relative values, selection, testing, etc. 6000 w. Ir & Coal Trds Rev—Sept. 23, 1904. No. 65453 A.

Rolling Methods.

The Rolling of Sections in Iron and Steel. Adolph S. While. Describes methods which have given entirely satisfactory results, giving drawings of the rolls and templates used. 2200 w. Ir Age—Oct. 13, 1904. Serial. 1st part. No. 65538.

Smelting.

A West African Smelting House. C. V. Bellamy. Illustrated account of methods now in use in the Colony of Lagos, West Africa, which are believed to be the same as those practiced by the earliest workers in this metal. 6000 w. Iron & Steel Inst—Oct., 1904. No. 65802 D.

Steels.

See Mechanical Engineering, Materials.

Sulphur.

A Radically New Method for the Determination of Sulphur in Irons and Steels. H. B. Pulsifer. Describes a new method devised by the author, much more rapid than the two methods at present recognized. 1400 w. Ir & St Mag—Oct., 1904. No. 65614 D.

Tennessee.

The Iron Ores of Shady Valley, Tennessee. F. Lynwood Garrison. Describes the creation, geology and deposits; their composition, value, etc. 3000 w. Eng & Min Jour—Oct. 13, 1904. No. 65551.

Wisconsin.

The Baraboo Iron Ore. N. H. Winchell. Discusses these deposits in Wisconsin, considering their structure, formation, etc., as discussed by Samuel Weidman in a recent publication. 4500 w. Am Geol—Oct., 1904. No. 65659 C.

MINING.

Alaska.

The Copper River Country, Alaska. W. R. Abercrombie. An interesting account of exploration work in this region. Ills. 7500 w. Jour Fr Inst—Oct., 1904. Serial. 1st part. No. 65437 D.

Blasting.

Large Blasting Operations in Slate Quarries. Illustrates and describes some unusually large blasts carried out in North Wales. 2200 w. Ir & Coal Trds Rev—Sept. 30, 1904. No. 65531 A.

Equipment.

English and German Designs for Electrical Mining Equipment. Frank C. Perkins. Gives illustrations of the power house at the Sneyd mine in Staffordshire, England, and considers details of German and English designs, the generating and lighting stations, distribution, electric haulage and winding machines, underground pumping plants, etc. 1600 w. Min Rept—Oct. 20, 1904. Serial. 1st part. No. 65672.

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Italy.

A Survey of the Mines and Mineral Industries of Italy. Enrico Bignami. Describing especially the sulphur deposits of Sicily. 3000 w. Engineering Magazine—Nov., 1904. No. 65775 B.

Mining Debris.

A Great Engineering Problem. W. A. Lawson. An account of the effort to be made to arrest the flow of mining débris in the Yuba River, and prevent its descent into the Feather, and so on to the Sacramento, to the detriment of navigation. 2500 w. Eng & Min Jour—Oct. 13, 1904. No. 65550.

Mining Law.

Mining Engineering and Mining Law. James D. Hague. Read at St. Louis, before the Int. Cong. of Arts and Sciences. Shows the important relations of the United States mining law to the vocation of the American mining engineer. 4500 w. Eng & Min Jour—Oct. 20, 1904. No. 65648.

Mining Machinery.

The Power Required for Mining Machinery (Kraftbedarf von Bergwerksmaschinen). J. L. Huber. Results of electric power measurements showing the amount and distribution of power, from observations in coal and salt mines. 1200 w. Glückauf—Oct. 1, 1904. No. 65763 D.

Ore Handling.

Ore-Handling Plant at the Clairton Works of the Crucible Steel Company. Charles H. Wright. An illustrated article describing how ore, limestone, and coke are conveyed from railroad cars to the furnace. 5500 w. Jour Assn of Engng Soc's—Aug., 1904. No. 65514 C.

Ore Mills.

Ore Mills at the Louisiana Purchase Exposition. Brief, illustrated descriptions of the working mills and models exhibited by California, Utah, and South Dakota. 2200 w. Mines and Min—Oct., 1904. No. 65395 C.

Quarrying.

The Cost of Quarrying Rubble and Dimension Stone for the Buffalo (N. Y.) Stone Breakwater. Emile Low. Briefly describes the method of quarrying, and gives figures of cost for 1903, from May to September, inclusive. Ills. 600 w. Eng News—Oct. 20, 1904. No. 65634.

Respiration.

Improved Respirators for Mining Service (Nouveaux Appareils Respiratoires en Usage dans les Mines). H. Schmerber. Describing the recent German devices for using oxygen in exploring and rescue work in mines. 3000 w. Génie Civil—Oct. 1, 1904. No. 65720 D.

Rock Drills.

The Action of Valve Gears in Pneumatic Rock Drills (Die Wirkungsweise der Steuerungen an Druckluft-Gesteinsbohrmaschinen). Carl Weidmann. A review of the different systems of operating the valves, with diagrams showing their action. 4500 w. Glückauf—Sept. 24, 1904. No. 65761 D.

Rock Movements.

Some Recent Rock Movements in the Laurentian and Huronian Areas. S. Dillon Mills. Read before the Can. Min. Inst. A statement of conclusions from a study of these regions. 3000 w. Can Min Rev—Sept. 30, 1904. No. 65402 B.

Safety Catch.

The Hoppe Safety Brake (Die Neue Hoppesche Fallbremse). W. Gentsch. Describing an improved safety catch for the cages of mine hoists. 1000 w. Zeitschr d Ver Deutscher Ing—Sept. 24, 1904. No. 65707 D.

The Karlik-Witte Safety Stop Apparatus for Hoisting Engines. Alfred Gradenwitz. Illustrated detailed description of the apparatus and its working. 2000 w. Min Rept—Oct. 13, 1904. No. 65600.

Sketching.

Sketching Mineral Veins. Prof. Arthur Lakes. An illustrated article on the methods of representing different rocks and minerals on sketches. 1200 w. Mines & Min—Oct., 1904. No. 65397 C.

Surveying.

Mine Surveying and Mapping. Charles E. Rowe. Describes a system which will be found useful in the surveying of flat or moderately pitched seams of coal, and parts of it may be applied to any underground surveying. 3000 w. Min Rept—Sept. 29, 1904. Serial. 1st part. No. 65390.

Tubbing.

Corrugated Tubbings (Gewellte Tubbings). Prof. Heise. A discussion of the use of corrugated metal for securing increased strength and lightness in lining shafts. 2500 w. Glückauf—Oct. 8, 1904. No. 65764 D.

Winding.

Computations for Electrically Driven Winding Machinery (Berechnung Elektrisch Betriebener Fördermaschinen). H. Koch & H. Schmiede. Developing formulas and diagrams showing the conditions involved in mine hoisting work, together with methods of regulating and controlling electric motors for winding service. 7000 w. Elektrotech Zeitschr—Sept. 22, 1904. No. 65736 B.

Winding Engines.

The Winding Engines of the Arnim

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Alexander Mine and the Prince Hohenlo Max Mine (Die Fördermaschinen auf dem v. Arnimschen Alexanderschacht und der Fürstlich Hohenloheschen Maxgrube). W. Gentsch. Illustrating an electrically driven mine hoist and a double steam winding engine. 1500 w. Zeitschr d Ver Deutscher Ing—Oct. 1, 1904. No. 65712 D.

MISCELLANY.

Bitumen.

The Origin of Bitumen. W. C. Morgan. Reviews the theories that have been advanced, and claims that it has been proven that bitumen is derived from animal sources, though it does not deny that there may also be other sources. 1300 w. Cal Jour of Tech—Sept., 1904. No. 65512 C.

Exposition.

Mining and Metallurgy at the St. Louis Exposition. H. Bauerman. A review of exhibits of interest to the iron and steel industry. 14000 w. Iron & Steel Inst—Oct., 1904. No. 65808 D.

Mercury.

Condition of the Quicksilver Industry in Brewster County, Texas. William B. Phillips. Gives information of the work of the various companies, with the opinion that the industry is in a healthy condition in spite of the closing down of two plants. 2000 w. Eng & Min Jour—Oct. 6, 1904. No. 65490.

The Determination of Mercury in Ores. W. W. Whitton. Reviews the methods for the determination of ores, especially the distillation-amalgamation assay, and gives a modification of this method. It is simple, quite accurate and requires no special apparatus. Ills. 2300 w. Cal Jour of Tech—Sept., 1904. No. 65511 C.

Minerals.

The Non-Metallic Mineral Products of the United States. Edwin C. Eckel. Gives facts relative to the geographic distribution and commercial development of the various non-metallic mineral products. Ills. and maps. 2500 w. Min Mag—Sept., 1904. No. 65351 C.

Salt.

Kansas Salt Industry. W. R. Crane. Illustrates and describes the methods employed in obtaining brines, and the arrangement of the evaporating and manufacturing apparatus. 3500 w. Mines & Min—Oct., 1904. No. 65396 C.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Electrification.

The Application of Electricity to Steam Railroads. Bion J. Arnold. Extracts from the President's address before the International Electrical Congress, St. Louis. 2500 w. R R Gaz—Vol. XXXVII., No. 17. No. 65492.

The Electrification of Steam Railways. F. F. Bennett. An endeavor to show that electrification of railways would be remunerative in thinly populated districts, as well as thickly populated, if the various companies would combine. 7800 w. Public Works—Oct. 15, 1904. No. 65623 D.

The Substitution of Electricity for Steam as a Motive Power. Abstract of a paper by Alexander Siemens, before the Int. Engng. Cong. A statement of conclusions reached thus far from the experimental work on the line between Marienfelde and Zossen. 2000 w. R R Gaz—Vol. XXXVII., No. 18. No. 65558.

Labor.

On the Question of Duration and Regulation of work. Pl. Weissenbach. (Subject XV for discussion at the seventh session of the Railway Congress). Report No. 1 for Switzerland. 11300 w. Bul Int Ry Cong—Sept., 1904. No. 65617 E.

On the Question of the Duration and Regulation of Work. Mr. Philippe. (Subject XV for discussion at the seventh session of the Railway Congress). For all countries, except America and Switzerland. 31000 w. Bul Int Ry Cong—Sept., 1904. No. 65618 E.

Operation.

Economical Train Operation. G. R. Henderson. Endeavors to make clear how the most efficient rating may be practically studied both as regards cost of operation and amount of business handled. 3000 w. Am Engr & R R Jour—Oct., 1904. Serial. 1st part. No. 65411 C.

Train Service.

British Autumn Train Services. Charles Rous-Marten. A review of the general scheme of train services for the autumn on the railways of Britain. 2000 w. Engr, Lond—Oct. 14, 1904. No. 65694 A.

MOTIVE POWER AND EQUIPMENT.

Cars.

American Freight Cars of Large Capacity (Amerikanische Güterwagen mit Grosser Ladefahigkeit). M. A. Nüscheler. A discussion of the economy attainable by the use of cars of large capacity; with examples from American practice. 2500 w.

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Glasers Annalen—Oct. 1, 1904. No. 65752 D.

Sixty-Foot-Horse Car, Central R. R. of New Jersey. Illustrated description of cars designed for the transportation of blooded stock. 600 w. Ry & Engng Rev—Oct. 8, 1904. No. 65507.

Coupler.

The Automatic Air and Steam Coupler. Illustrated description of the undersized automatic air and steam coupler as manufactured by the Westinghouse Air Brake Co. 400 w. Loc Engng—Oct., 1904. No. 65417 C.

Grates.

The Relative Merits of Large Grates and Heating Surfaces and Their Proportions. Extracts from the report of the Committee on Coal Consumption in Locomotives, read at the last convention of the Am. Ry. Mas. Mechs. Assn. Also discussion. 5700 w. Pro W Ry Club—Sept. 20, 1904. No. 65654 C.

Locomotives.

American Locomotives. Abstract of a paper by William Forsyth, presented before the Int. Engng. Cong. Discusses modern designs, the changes made in four-cylinder balanced compounds, boilers, etc., and the operation of locomotives as affected by the fireman, valves, etc. 6000 w. R R Gaz—Vol. XXXVII., No. 18. No. 65555.

Express Passenger Engine, London and North-Western Railway. Illustrations, with dimensions of a new type of express engine for working heavy high-speed passenger traffic. 400 w. Engr, Lond—Oct. 14, 1904. No. 65695 A.

Express Passenger Locomotive for the London and South-Western Railway. Illustrated description, with dimensions. 900 w. Engng—Sept. 23, 1904. No. 65450 A.

Negative Work of Back Pressure and Compression. Ira C. Hubbell. Claims that compression is negative, and that by delaying the closure of the exhaust part the volume in compression is decreased and also the negative work, and consequently the work to be obtained from a given quantity of steam is increased. Discussion follows. 11000 w. Pro W Ry Club—Sept. 20, 1904. No. 65653 C.

New Compound Locomotives in Bavaria. Charles R. King. An illustrated description of locomotives largely representative of the most approved and latest European practice, with discussion of details. 2500 w. R R Gaz—Vol. XXXVII., No. 19. No. 65657.

New Locomotives for the Southern Pacific. Brief illustrated description of four recent locomotives, three of which use oil as fuel. 500 w. R R Gaz—Vol. XXXVII., No. 16. No. 65368.

Recent Locomotives for Local Traffic (Neuere Vorortzug-Lokomotiven). E. Metzeltin. Illustrating and describing a number of small engines for local service, from recent German designs. Serial. Part I. 3000 w. 1 plate. Zeitschr d Ver Deutscher Ing—Oct. 1, 1904. No. 65709 D.

Six-Coupled Locomotive for the Pekin Syndicate Railways. Illustration and principal dimensions. 500 w. Engng—Sept. 30, 1904. No. 65525 A.

Ten Wheel Passenger Locomotive, with Wide Firebox Boiler.—C. B. & Q. Lines West. Dimensions and description. 1000 w. Ry Mas Mech—Oct., 1904. No. 65599.

The Cole Balanced Compound Locomotive at the St. Louis Exhibition. H. W. Hanbury. Perspective view, general drawing and description. 2000 w. Engng—Oct. 21, 1904. No. 65837 A.

The Cross-Compound Locomotive. W. L. Kinsell. Gives a report of tests made on the Chicago, Great Western Railway, which emphasize the necessity for a careful study of the power distribution of these engines. 1200 w. Am Engr & R R Jour—Oct., 1904. No. 65413 C.

The Locomotive Exhibits at the St. Louis Exhibition. Illustrations and leading dimensions of the engines, with particulars, also editorial. 4800 w. Engng News Oct. 6, 1904. No. 65476.

Locomotive Tests.

Tests of Locomotives on the French State Railway. Abstract of articles by Joseph Nadal, appearing in the *Revue Generale des Chemins de Fer*. An account of tests made of five different types of locomotives, for the purpose of examining the efficiency of operation of the steam in the cylinders, and other matters of interest. The results are discussed. 1600 w. R R Gaz—Oct. 28, 1904. Serial. 1st part. No. 65833.

Motor Cars.

Motor Cars for Light Passenger Traffic on Steam Railways. Gives information of lines in England and the United States, and a report on motor cars on European railways. 4000 w. Eng News—Oct. 13, 1904. No. 65541.

Rolling Stock.

Locomotives and Other Rolling Stock. Abstract of a paper by Edouard Savage, presented to the International Engineering Congress, St. Louis. Considers modern locomotives and their performance on French railroads, with brief reference to passenger carriages and goods wagons. 3000 w. R R Gaz—Vol. XXXVII., No. 17. No. 65493.

Rolling Stock on the Leek and Manifold Light Railway. Illustrated description of cars for a 2 ft. 6 in. gauge. 800 w. Engr, Lond—Oct. 21, 1904. No. 65842 A.

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Trucks.

Flange Wear and Side Bearing Trucks. Gustav Lindenthal. Shows the forces that produce flange wear and the way to reduce them, with a view to economy. Full paper and discussion. Ills. 9700 w. N Y R R Club—Sept. 16, 1904. No. 65594.

NEW PROJECTS.

Australia.

Western Union Railway of Australia. Information concerning Australian railways, and the proposed construction of a line connecting the systems of Western and Southern Australia. 1400 w. Engr, Lond—Oct. 14, 1904. No. 65699 A.

Ecuador.

Construction Difficulties on the Guayaquil & Quito Railway. An illustrated article describing the building of this railroad in the tropics. 1500 w. Eng Rec—Oct. 22, 1904. No. 65666.

Italy.

The Proposition for a New Apennine Railway from Genoa to Tortona (Die Erstellung einer Neuer Apenninbahn von Genua nach Tortona). E. Bavier. With profile and plan of the route, which includes a tunnel 20 kilometres in length at Rigoroso. Two articles. 4000 w. Schweiz Bauzeitung—Sept. 17, 24, 1904. No. 65765 each B.

PERMANENT WAY AND BUILDINGS.

China.

The Actual Building of a Chinese Railway. Justin Burns. A fully illustrated account of the operative conditions of railway construction on the Canton-Hankow Railway. 4000 w. Engineering Magazine —Nov., 1904. No. 65773 B.

Construction.

The St. Louis, Kansas City & Colorado. J. L. Campbell. Illustrated description of a new line constructed on an exceptionally permanent basis for a new road. 4500 w. R R Gaz—Vol. XXXVII., No. 19. No. 65656.

Crossties.

On the Question of Wooden Sleepers or Cross Ties. Mr. Hausser. Report for all countries except America. Selection of species of timber used and processes of preservation. (Subject 1-A, for discussion at the seventh session of the Railway Congress). 7000 w. Bul Int Ry Cong—Sept., 1904. No. 65616 E.

Ditching Costs.

Cost of Ditching Cuts and Widening Embankments. Extracts from a committee report to the St. Louis meeting of the Roadmasters and Maintenance-of-Way Assn. 3500 w. R R Gaz—Vol. XXXVII., No. 19. No. 65658.

Engine Houses.

Square Engine House—Terminal Railroad Association of St. Louis. Illustrated description of the houses serving the passenger engines during the World's Fair. 2200 w. Ry Mas Mech—Oct., 1904. No. 65598.

Rails.

Some Notes on the Creeping of Rails. Discussion of paper by Samuel Tobias Wagner. 7000 w. Pro Am Soc of Civ Engrs—Oct., 1904. No. 65821 E.

Signals.

Controlled Manual Block Signals—Illinois Central. Illustrates and describes a manually controlled block system installed on certain single-track lines carrying heavy traffic. 1200 w. Ry Age—Oct. 7, 1904. No. 65501.

On the Question of the Automatic Block System. (Subject X for discussion at the seventh session of the Railway Congress.) C. H. Platt. Report for America. Ills. 11000 w. Bul Int Ry Cong—Sept., 1904. No. 65619 E.

Lightning and Automatic Block Signals. H. S. Balliet. A discussion of the kinds of fractures due to lightning, the cause and the efforts to correct these troubles. Ills. 2200 w. R R Gaz—Vol. XXXVII., No. 16. No. 65366.

Terminals.

Railroad Terminals. Elmer L. Corthell. Read before the Int. Engng Cong., St. Louis. Classifies the types of large stations, discussing them in detail and giving interesting tables. 6000 w. Ry & Engng Rev—Oct. 8, 1904. No. 65508.

Tracks.

Rearrangements of Tracks and Station Facilities at the Union Station, St. Louis, Mo. An illustrated description of the arrangements made for handling the great increase in traffic during the World's Fair. 5200 w. Eng News—Sept. 29, 1904. No. 65372.

Track Depression of the Chicago & Northwestern Railway at Milwaukee. An illustrated description of work presenting features of great interest, the object being the separation of the traffic of the railway from the city streets. 2000 w. Ry Age—Oct. 14, 1904. No. 65560.

Trestles.

The Care of Railroad Trestles While Being Filled. From a report presented at the convention of the Assn. of Ry. Supts. of Bridges and Buildings on the best methods of caring for trestles while being filled. 2400 w. Eng Rec—Oct. 22, 1904. No. 65665.

TRAFFIC.

Parcels.

Small Parcels Traffic in England. De-

scribes the methods employed by the London & Northwestern Railway as typical of general practice. 3500 w. Ry Age—Oct. 2, 1904. No. 65661.

Per Diem.

Comments on the Per Diem Rules. Arthur Hale. Comments on the rules in their order. Also editorial. 4500 w. Ry Gaz—Vol. XXXVII., No. 18. Serial. 1st part. No. 65553.

Pooling.

On the Question of Pooling Locomotives (Subject VI. for Discussion at the Seventh Session of the Railway Congress). Mr. Bell. Report (No. 1) for all countries, except United States, Belgium, England and Colonies, Holland, Denmark, Russia, Sweden and Norway. 4000 w. Bul Int Ry Cong—Sept., 1904. No. 65615 E.

United States.

Traffic on Improved Waterways and Railroads in the United States. Edward P. North. Extracts from a paper read before the Int. Engng. Cong. Gives much information of the development of transportation facilities in the United States, and the causes that have made possible the low rates as compared with other countries. 4000 w. R R Gaz—Vol. XXXVII., No. 18. No. 65556.

MISCELLANY.

India.

Railways in British India. Information of interest relating to the railways of India. 2500 w. Ry Age—Oct. 7, 1904. Serial. 1st part. No. 65500.

Specifications.

Standard Specifications for Mechanical Interlocking Material and Construction Work. Extracts from a set of specifications submitted at the annual convention of the Railway Signal Assn., at St. Louis. 2000 w. Eng News—Oct. 20, 1904. No. 65638.

STREET AND ELECTRIC RAILWAYS

Basle.

Electric Power Plant—Basle Tramways. A general illustrated description of the extension of the Basle system. 1400 w. Trac & Trans—Oct., 1904. No. 65536 E.

Boosters.

"Negative" Boosters. J. Stanley Richmond. Part first contains a theoretical and experimental discussion of the return current in electric railways, with diagrams. 3000 w. Elec Rev, N. Y.—Oct. 8 & 15, 1904. Serial. 2 parts. No. 65504.

Brooklyn.

Rapid Transit Railway Construction in Brooklyn. The present article gives an illustrated description of work on Section 3, Division 5, which extends from Flatbush and Atlantic Avenues to Clinton and Joralemon Sts. 3300 w. Eng Rec—Oct. 22, 1904. Serial. 1st part. No. 65669.

Burma.

Electric Tramway in Mandalay. Illustrated detailed description of the first electric railway in Burma, which has been in operation two or three months. 1500 w. Elec Engr, Lond—Sept. 30, 1904. No. 65520 A.

Electric Tramways in Mandalay. Illustrates and describes recently opened tramway route 7 miles in length, double-track throughout. 1500 w. Tram & Ry Wld—Oct. 13, 1904. No. 65827 B.

Cable Incline.

Inclined Cable Road Up to the Hohensyburg, Westfalen Province, Germany. Franz Koester. Illustrated detailed description. 1500 w. Elec Rev, N. Y.—Oct. 8, 1904. No. 65503.

The Funicular Railway of Bourboule (Le Funiculaire de la Bourboule). A. Dumas. Describing a cable incline railway from the village of Bourboule, Auvergne, to a plateau 300 metres above, with an account of the hydroelectric station. 2000 w. 1 plate. Génie Civil—Sept. 17, 1904. No. 65714 D.

Cars.

Cars: Their Equipment and Maintenance. John Aldworth. Read at the Liverpool Congress of the Munic. Tram. Assn. of Gt. Britain. Considers the more important features, giving observations based on methods in operation on the Nottingham system. 3500 w. Elec Engr, Lond—Sept. 30, 1904. No. 65521 A.

General Design and Finish of the Modern Interurban Car. Edward C. Boynton. An illustrated description of recent improvements introduced in interurban cars. 1200 w. St Ry Jour—Oct. 1, 1904. No. 65405 C.

Conduit.

South London Conduit Tram Lines. Illustrates and describes the reconstruction of these tramways on the conduit system. 3500 w. Engr, Lond—Sept. 23, 1904. No. 65451 A.

Current Consumption.

Economy in Consumption of Current.

We supply copies of these articles. See page 475.

Peter Fisher. Read before the Munic. Tram. Assn., Liverpool, England. Discusses the subject generally and gives information received in reply to a set of questions circulated. 7800 w. Tram & Ry Wld—Oct. 13, 1904. No. 65828 B.

Development.

Street Railways During the Last Decade. A brief sketch of the steps by which this industry has grown since 1894. 6000 w. St Ry Jour—Oct. 8, 1904. No. 65456 C.

Double-Deck.

Double-Deck Cars for Twin Cities Illustrated description of a double-deck trolley car for use between St. Paul and Minneapolis. 500 w. St Ry Rev—Oct. 13, 1904. (Daily Ed.) No. 65595 C.

Electrical Equipment.

Maintenance and Inspection of Electrical Equipment. John Lindall. Read before the Am. Ry. Mech. & Elec. Assn. Suggestions, with a brief description of inspection and repairs of electrical equipment on the Boston Elevated Ry. 2500 w. St Ry Rev—Oct. 12, 1904. (Daily Ed.) No. 65547 C.

Gearing.

Worm Reduction in Electric Tramway Equipments. O. F. Domon. Illustrates and describes a new car with worm reduction gear recently placed on the Seebach-Oerlikon-Zurich Electric Tramway for trial. 1000 w. Elec Rev, Lond—Oct. 21, 1904. No. 65847 A.

Hydro-Electric.

Hydraulics in Connection with Electric Railway Work. B. E. Morrow. A general discussion of the advantages of water power for this work, and the points needing attention in such a plant. 3000 w. St Ry Rev—Sept. 20, 1904. No. 65474 C.

Illinois.

McKinley Syndicate Properties of Central Illinois. Describes properties, including city and suburban lines, which will eventually reach from Danville to St. Louis. 5500 w. St Ry Rev—Sept. 20, 1904. Serial. 1st part. No. 65475 C.

Instruction Car.

An Underground Instruction Car. Illustrated description of the car equipped for the Subway Division of the Interborough Rapid Transit Co., of New York. 900 w. Loc Engng—Oct., 1904. No. 65416 C.

Locomotive.

Electric Goods Locomotive. Illustrated description of a locomotive for service on the electrified branch of the North-Eastern Railway Company's system at Newcastle. 800 w. Engng—Oct. 14, 1904. No. 65692 A.

Mixed Traction.

Methods of Dealing with Mixed Systems of Traction. A. L. C. Fell. Read before the Liverpool Cong. of the Munic. Tram. Assn. of Gt. B. Considers temporary mixed traction during reconstruction; mixed traction under normal conditions; and mixed traction in connection with running powers. 2000 w. Elec Engr, Lond—Oct. 7, 1904. No. 65584 A.

Mountain Railway.

The Stansstad-Engelberg Electric Railway. Emile Guarini. An illustrated detailed description of a narrow-gauge, mountain electric railway in Switzerland. 2000 w. R R Gaz—Vol. XXXVII., No. 18. No. 65557.

New Jersey.

Some Operating Features of the Electric Railway System Controlled by the Public Service Corporation of New Jersey. A. H. Stanley. Illustrates and describes the property of this company, its equipment and operation. It comprises 550 miles of overhead trolley system. 5000 w. St Ry Rev—Sept. 20, 1904. No. 65472 C.

N. Y. Subway.

Opening of the New York Rapid Transit Subway. An illustrated article dealing mainly with the great power station at Fifty-ninth Street and the North River. 2000 w. Sci Am—Oct. 29, 1904. No. 65818.

Passenger Stations and Engineering Details of the New York Subway System. An illustrated detailed description of many interesting features. 5000 w. St Ry Jour—Oct. 1, 1904. No. 65404 C.

The Electric Generating Equipment and Power Distribution System of the New York Rapid Transit Subway. L. B. Stillwell. A full illustrated description of the details of this system, with related information of interest. 5000 w. St Ry Jour—Oct. 8, 1904. No. 65458 C.

The Steam Generating and Engine Equipment of the Power Plant. John Van Vleck. An illustrated detailed description of the construction and equipment of the power plant for the New York Rapid Transit Subway. 9500 w. St Ry Jour—Oct. 8, 1904. No. 65457 C.

Underground Rapid Transit in New York City. Begins a detailed description of this great engineering work. The present number outlines the routes, and begins an illustrated description of the power plant, and its equipment. 8000 w. Elec Wld & Engr—Oct. 8, 1904. Serial. 1st part. No. 65494.

Northampton.

Northampton Electric Tramways. Illustrated detailed description. 3500 w.

We supply copies of these articles. See page 475.

Tram & Ry Wld—Oct. 13, 1904. No. 65826 B.

Oregon.

The Territory, Construction, Power Transmission System and Rolling Stock of the Oregon Water Power & Railway Company. Begins an illustrated detailed description of an electric system having many interesting features, and carrying on a large passenger and also freight business. 5800 w. St Ry Jour—Oct. 22, 1904. Serial. 1st part. No. 65675 C.

Overhead Equipment.

Overhead Equipment: Notes on its Construction and Maintenance. J. M. McElroy. Read at the Liverpool Congress of the Munic. Tram. Assn. of Gt. Britain. Discusses the best and most suitable methods of constructing and maintaining the equipment. 3500 w. Elec Engr, Lond—Sept. 30, 1904. No. 65522 A.

Power Station.

See Electrical Engineering, Generating Stations.

Railway Motors.

See Electrical Engineering, Motors.

St. Louis.

The Electric Railways of St. Louis. An illustrated article giving a brief summary of the situation. Also an illustrated description of the new central sub-station of the St. Louis Transit Company, by Charles A. Hobein. 3300 w. St Ry Jour—Oct. 8, 1904. No. 65455 C.

Signals.

Automatic Electric Block Signals. Mellen C. M .Hatch. Illustrates and describes a system recently installed between Oakland and Port Costa, California, explaining its operation. 3000 w. Cal Jour of Tech—Sept., 1904. No. 65509 C.

The Block Signal and Interlocking Systems of the Subway Division of the Interborough Rapid Transit Company. An illustrated detailed description of the electro-pneumatic system installed and the conditions it was designed to meet. 6000 w. St Ry Jour—Oct. 8, 1904. No. 65460 C.

Single-Phase.

Single-Phase Electric Traction (La Traction par Courant Alternatif Simple). An illustrated account of the Spindlersfeld-Niederschöneweide line, describing the Winter-Eichberg motor, with diagrams of tests. 1800 w. Génie Civil—Oct. 8, 1904. No. 65722 D.

Steel Cars.

Fireproof Cars—New York Subway. Illustrated description of the steel passenger cars and the difficulties overcome in their construction. 1500 w. Am Engr & R R Jour—Oct., 1904. No. 65412 C.

Steel Cars for the New York Subway. A statement of the conditions to be considered in designing cars for the subway, with brief description of the first cars built, and illustrated description of the later cars designed by George Gibbs, which are almost entirely of steel. 1500 w. R R Gaz—Sept. 30, 1904. No. 65367.

The New Steel Cars for the Subway Division of the New York Interborough Rapid Transit Company. Reviews the development of the designs for the rolling stock equipment, stating the conditions, and giving an illustrated detailed description of the absolutely fire-proof cars finally evolved. 5500 w. St Ry Jour—Oct. 8, 1904. No. 65459 C.

Steel Track.

Hadfield's Special Steel Track-Work. Illustrated description of street railway track work on the conduit system recently laid in South London. Also editorial. 2000 w. Engng—Sept. 23, 1904. No. 65449 A.

Switzerland.

The St. Gallen, Speicher, Frogen Electric Railway (Die Strassenbahn St. Gallen-Speicher-Frogen). S. Herzog. Describing a Swiss interurban road about six miles long, taking the current from the generating station at Kubel. 2500 w. Zeitschr d Ver Deutscher Ing—Sept. 17, 1904. No. 65702 D.

Third Rail.

Third-Rail System of the Scioto Valley Traction Co., Columbus, Ohio. Illustrates and describes the interesting features of this high speed electric road. 7500 w. St Ry Rev—Sept. 20, 1904. No. 65471 C.

Three-Phase.

The Ganz Three-Phase Electric Railway System. G. Leve. A discussion of the advantages and disadvantages of the three-phase motor, and information concerning the Valtellina line. Ills. 3300 w. R R Gaz—Vol. XXXVII., No. 16. No. 65369.

Trucks.

Electric Traction Trucks. Elmer E. Cook. Describes the main types of trucks in use, with some account of their performances. Ills. 5600 w. Trac & Trans—Oct., 1904. No. 65535 E.

Underground.

The London Underground Railways. Map, with description of improvements being made to facilitate transit of passengers. 2800 w. Ry Age—Oct. 21, 1904. No. 65662.

See also Railway Engineering.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

Serial publications are indexed on the appearance of the first installment.

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Each coupon will be received by us in payment for any 20-cent article catalogued in the Index. For articles of a higher price, one of these coupons will be received for each 20 cents; thus, a 40-cent article will require two coupons; a 60-cent article, three coupons; and so on. The use of these coupons is strongly commended to our readers. They not only reduce the cost of articles 25 per cent. (from 20c. to 15c.), but they need only a trial to demonstrate their very great convenience—especially to engineers in foreign countries, or away from libraries and technical club facilities.

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CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Review. *m.* Montreal.
Cassier's Magazine. *m.* New York.
Cement. *b.-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.

Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Magazine. *m.* New York.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Page's Weekly. *w.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Public Works. *m.* London.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.

CURRENT RECORD OF NEW BOOKS

NOTE—*Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post Office Orders, home and foreign, should be made payable to* THE ENGINEERING MAGAZINE.

Boiler Construction.

Boiler Construction. By Frank B. Kleinhans. Size, 8 by 5½ in.; pp. 421; plates, 5; figures, 334. Price, $3. New York: The Derry-Collard Co. London: The Locomotive Publishing Co., Ltd.

As indicated by its secondary title, this book contains "a practical explanation of the best modern methods of boiler construction from the laying out of sheets to the completed boiler." It is essentially practical and goes thoroughly into the details of the various operations described, so that anyone mastering it should have as correct an idea of boiler construction as is possible without actually seeing the work done. The locomotive boiler is taken as an example of steam boilers in general, as it is in such extensive use, and as its design and construction present perhaps more difficulties than those of any other type, and anyone capable of following some of its complicated sheets from the laying-out bench through the hydraulic press and the riveting machine to the finishing processes will be able to handle the sheets of other styles of boilers. The different operations are taken up in regular order, beginning with the laying-out of the sheets. Flanging, forging, shearing, planing, punching, bending, riveting, and all the other processes are minutely set forth, and the boiler details are carefully described, as are also all the tools and machines used in boiler construction. Line drawings and half-tones, in the text and on plates, supplement the descriptions, and many tables of useful data and an index add to the value of a very up-to-date work.

Drawing.

Elements of Plane and Solid Free-Hand Geometrical Drawing, with Lettering and Some Elements of Geometrical Ornamental Design. By S. Edward Warren, C. E. Size, 8 by 5 in.; pp. 137; 12 plates, and many figures in the text. Price, $1 (4s. 6d.). New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Drafting Instruments and Operations. By S. Edward Warren, C. E. Size, 8 by 5 in.; pp. 152; 100 figures and 7 plates. Price, $1.25 (5s. 6d.). New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Elementary Projection Drawing, Theory and Practice. By S. Edward Warren, C. E. Size, 8 by 5 in.; pp. 162; 24 plates, and figures in the text. Price, $1.50 (6s. 6d.). New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Elementary Linear Perspective of Form and Shadow. By S. Edward Warren, C. E. Size, 8 by 5 in.; pp. 121; figures, 67; plates, 2. Price, $1 (4s. 6d.). New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Many college generations of students are familiar with Prof. Warren's treatises on descriptive geometry, shades and shadows, stone-cutting and other higher branches of mathematical drawing, and have had their imaginations quickened and their reasoning powers strengthened by the exercises and problems there presented, and some of them have also made the acquaintance of his more elementary works. All of these men will welcome the appearance of new editions of the works under review, which form the four parts of a series on Industrial Science Drawing, and also serve as an introduction to the author's more advanced writings; and the student and draftsman of to-day will find in these books a systematic course of instruction founded on the principles which have been instrumental in training many of the greatest engineers of the age. While following the broad lines laid down in the earlier editions, which have been so successful in the past, the present works have been revised to meet the needs of the changing times. The titles of the volumes are a sufficient indication of their general contents, and where there is so much of value, it is difficult to single out special features for treatment in such a limited space, but one subject, which it is unusual to find in a work of this kind, may be mentioned: Part III. of the book on Free-Hand Geometrical Drawing is devoted to the "Elements of Geometric Beauty," and contains several chapters on the æsthetic aspects of drawing, geometry and architecture which are most interesting and suggestive. It is hardly necessary to add, with the names that appear on the title pages, that the mechanical execution of these volumes is up to the high standard of their subject matter.

Electricity.

Modern Practical Electricity. Electricity in the Service of Man. A Popular and Practical Treatise on the Application of Electricity in Modern Life. By R. Mullineux Walmsley, D. Sc. (Lond.), F. R. S. E. Four volumes. Size, 10 by 7 in.; pp. 1240; 1208 illustrations in the text and a number of plates. Price, $12 for the set. Chicago: W. T. Keener & Co.

The marvellous increase in the applications of electricity to the service of man is perhaps the most striking phenomenon of the last quarter century, and it is but a commonplace to say that everyone should know as much as possible about electrical science and its practical developments. The question is, how to acquire this knowledge. Most people have neither the opportunity nor the inclination for a lengthy course of study or a working apprenticeship, and must get their information, if at all, from books which they can read in their leisure moments. To all such persons the work under review may well appeal, for it is both "a popular and practical treatise on the applications of electricity in modern life." It is scientifically sound, but is not too technical for the average man, and it covers a very great deal of ground in an effective manner. The work is divided into two main parts, "the history and principles of electrical science" and "the technology of electricity." The former contains an excellent review of the development of the various branches of the science and its practical applications, bringing the accounts right down to the present time and describing the most modern, as well as the historical apparatus and machines. The second part goes more into the details of present-day electrical engineering, but in a plain, straightforward way which can be understood by the general reader as well as by the student. A profusion of diagrams and illustrations adds greatly to the value of the volumes, and an index completes a work which is really encyclopedic in scope.

Heat Losses.

Practical Laws and Data on the Condensation of Steam in Covered and Bare Pipes, to which is added a Translation of Péclet's "Theory and Experiments on the Transmission of Heat Through Insulating Materials." By Charles P. Paulding, M. E. Size, 9 by 6 in.; pp. 102; figures, 185. Price, $2. New York: D. Van Nostrand Company.

More than half a century ago the French physicist Péclet made extensive researches on the radiation of heat from different surfaces and the conduction of heat through various materials. The laws and formulæ which he deduced from his investigations form a theory of these phenomena which serves well as a basis for tests along these lines, and the most recent experiments on the loss of heat from covered and bare steam pipes give results in agreement with his work. Although Péclet's general conclusions have long been known to English-speaking engineers, it remained for the author of the present book to give a complete translation of those parts of Péclet's "Treatise on Heat" which have a direct bearing on practical problems of the present day, and to show how the French physicist's methods may be applied in steam engineering and heating work. Some of the latest tests on the loss of heat from covered steam pipes are here compared and discussed, and tables and curves are given which will do much to facilitate and systematize further investigations, the author's experience having qualified him to determine what is most useful to engineers in these fields.

Naval Architecture.

Naval Architecture. By Cecil H. Peabody. Size, 9 by 5¾ in.; pp. v, 616; figures, 217. Price, $7.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Recognizing the fact that if America is to build up her navy and her mercantile fleet she must have trained naval constructors and marine engineers, several of the great technical schools of the United States have organized courses in naval architecture, and it is the head of this department at the Massachusetts Institute of Technology who is the author of the present volume. While designed primarily as a text book, this work will be found very useful by naval architects and shipbuilders in general, as it develops its subject in a clear and logical manner, establishing the principles of naval architecture and showing their practical application by many appropriate examples. The opening chapter gives the various methods for computing areas, and a discussion of graphical integration and of mechanical integrators. The subjects of displacement, center of buoyancy and stability are then taken up, and next comes a complete discussion of surfaces of buoyancy and water-lines. Then follow chapters on adding and moving weights, on grounding and docking and on launching, in which the different kinds of docks and ways of launching are described, and the methods for determining displacement and stability extended and applied to these operations. There is a comprehensive treatment of the theory of waves, and also a discussion of the rolling of ships, including a description of experiments on a large scale and of means for diminishing roll-

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ing. The chapters on the resistance of ships, the propulsion of ships and power for ships form a very important portion of the book, and contain a great deal of valuable matter, including a discussion of the screw propeller. Steering and manœuvring, including a description of different forms of rudders, take up another section, and the final chapter is devoted to the weight and strength of ships. Many diagrams and tables help to elucidate the text. and the work is completed by an index.

Printing.

Concerning Type. A Hand-Book of Useful Information for Advertisers and Users of Printing. By Ambrose S. Carnell. Size, 6 by 3 in.; pp. 64; illustrations. Price, 50 cents. New York: Ambrose S. Carnell.

Besides being the "art preservative," printing might lay claim to the title of the art conservative, for it is permeated with traditions and terms handed down from remote antiquity, but even this art must grow with the growing age, and among the innovations of recent years has been the adoption of the "point system" by all the typefounders of the United States, which has brought about an absolute uniformity of the different sizes of type, instead of having a variety of standards, as under the old lack-of-system, when each founder had his own idea as to the proper sizes for nonpareil, brevier, long primer and the rest. Styles of type change, too; new faces are designed and the old ones become modified. Exact information concerning these developments, which has heretofore been scattered in many places, more or less inaccessible, has now been gathered together in convenient form in the present hand-book. But this book not only tells about type, but also contains some account of half-tones, line-cuts and electrotypes, a glossary of printing terms, advice about "copy," proofs, and proof-reading, tables giving the number of ems to the square inch for different sizes of type, approximate number of words to the square inch, amount of paper required for a job, sizes of paper and envelopes, and a great deal of other information essential for both printer and editor.

Rapid Transit.

Interborough Rapid Transit: The New York Subway; Its Construction and Equipment. Size, 13½ by 10 in.; pp., 150. Many illustrations. New York: Interborough Rapid Transit Company.

The opening of the underground railway in New York affords an appropriate occasion for the appearance of this elaborate souvenir publication, which, by illustration and text, describes all the features of the great undertaking. As is well known, the Rapid Transit Railway, or Subway, for which New Yorkers have waited so long, extends from the City Hall and the Brooklyn Bridge to Kingsbridge, just north of Spuyten Duyvil Creek, a distance of 13½ miles, with an easterly branch about 7 miles long, which leaves the main line near 103d Street and runs under the Harlem River to Bronx Park. There is also under construction an extension of the road to Brooklyn, about 3 miles in length, which runs from the City Hall down Broadway to South Ferry and under the East River to a terminus at Flatbush and Atlantic avenues. The greater part of the road is under ground, but about two miles in the upper part of Manhattan Island and three miles in the Borough of the Bronx are on viaduct. The present book opens with a historical and general review of the Rapid Transit Road, and then takes up the various parts of the enterprise, including the underground construction, the track, the signal system, the cars and their equipment, the great power station and other features. All of these are fully and interestingly described, and beautifully illustrated, and the whole execution of this souvenir volume is worthy of the great engineering work to which it is devoted.

Wireless Telegraphy.

Maxwell's Theory and Wireless Telegraphy. Part I: Maxwell's Theory and Hertzian Oscillations. By H. Poincaré. Translated by Frederick K. Vreeland. Part II: The Principles of Wireless Telegraphy. By Frederick K. Vreeland. Size, 8½ by 6 in.; pp. xi, 255; figures, 145. Price, $2.00. New York: McGraw Publishing Company.

The art of wireless telegraphy has now reached a stage where a comprehensive survey of the principles on which it is based is in order, and such a review of the theory of Hertzian waves and their application to the transmission of intelligence through space forms the subject matter of the present work. The first part of the book is a translation of Prof. Poincaré's luminous exposition of "Maxwell's Theory and Hertzian Oscillations," in which mathematics is practically eliminated, the Maxwellian equations being converted into the language of every-day life, and illustrated by mechanical analogies and diagrams, most of the latter having been especially prepared by the translator. In the second part the application of the fundamental principles of electrical science to space telegraphy is taken up, the development of the subject being continued in a logical manner, and the two parts of the treatise being so well matched that no break in the continuity of the story can be observed. While no attempt has been made to catalogue the innumerable devices which have

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sprung up with the growth of the art, the typical systems and pieces of apparatus are well described wherever they are necessary to the general development of the subject. In this second part, after the introductory and historical portion, there are chapters on the grounded oscillator; propagation of grounded waves; the receiving apparatus, and selective signaling. The chapter on grounded waves gives an excellent discussion and summary of the hypotheses concerning the modus operandi of the electric waves between the transmitter and the receiver, and the other chapters are no less clear and interesting, emphasizing the essential and omitting the superfluous. The translation of Prof. Poincaré's monograph is very well done, both technically and from the point of view of style, and the whole work gives a remarkably good treatment of the theory of electric waves and their application to wireless telegraphy, in a manner which is scientific in the best sense of the word.

BOOKS RECEIVED.

The Industrial and Artistic Technology of Paint and Varnish. By Alvah Horton Sabin. Price, $3. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Types and Details of Bridge Construction. Part I. Arch Spans. By Frank W. Skinner. Price, $3. New York: McGraw Publishing Company.

Forge Practice. By John Lord Bacon. Price, $1.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Alternating Current Engineering Practically Treated. By E. B. Raymond. Price, $2.50. New York: D. Van Nostrand Company. London: Kegan Paul, Trench, Trübner & Co., Ltd.

An Introduction to the Modern Theory of Equations. By Florian Cajori, Ph. D. Price, $1.75. New York: The Macmillan Company. London: Macmillan & Co., Ltd.

The Art of Wise Investing, Price, $1. New York: Moody Publishing Co.

The "Mechanical World" Pocket Diary and Year Book for 1905. Price, 6d (25 cents). Manchester, Eng.: Emmott & Co., Ltd.

Electrical Lighting: A Practical Exposition of the Art. Volume I. The Generating Plant. By Francis B. Crocker. Sixth edition. Price, $3. New York: D. Van Nostrand Company. London: E. & F. N. Spon, Ltd.

The Electrical Transmission of Energy: A Manual for the Design of Electrical Circuits. By Arthur Vaughan Abbott. Fourth edition. Price, $5. New York: D. Van Nostrand Company. London: Crosby Lockwood & Son.

Reinforced Concrete. By Charles F. Marsh. Price, $7. New York: D. Van Nostrand Company.

Mechanical Appliances, Mechanical Movements, and Novelties of Construction. By Gardner D. Hiscox. Price, $3. New York: The Norman W. Henley Publishing Company.

Tractive Power Chart. Price, 50 cents. New York: The Derry-Collard Co.

British Sewage Works. By M. N. Baker. Price, $2. New York: The Engineering News Publishing Company.

Scientific American Reference Book. Compiled by Albert A. Hopkins and A. Russell Bond. Price, $1.50. New York: Munn & Company.

Elements of Mechanical Drawing. By Alpha Pierce Jamison. Price, $2.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Earth Dams. By Burr Bassell. Price, $1. New York: The Engineering News Publishing Co.

Electrical Engineering Experiments and Tests of Direct Current Machinery. By George F. Sever. Price, $1. New York: D. Van Nostrand Company.

Experiments with Alternate Currents of High Potential and High Frequency. By Nikola Tesla. New edition. Price, $1. New York: McGraw Publishing Company.

Self-Propelled Vehicles. By James E. Homans. Second revised edition. Price, $2. New York: Theo. Audel & Co.

Friction and Lubrication. By Wm. M. Davis. Second edition. Price, $2. Pittsburg: The Lubrication Publishing Co.

Twentieth Century Hand-Book for Steam Engineers and Electricians. By C. F. Swingle. Electrical Division, by Henry C. Horstmann and Victor H. Tousley. Price, $2.50. Chicago: Frederick J. Drake & Co.

Untechnical Addresses on Technical Subjects. By James Douglas. Price, $1. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Australian Mining and Metallurgy. By Donald Clark. Price, 21s. Melbourne, Sydney and Perth: Critchley Parker.

The Architects' Directory and Specification Index for 1904-05. Price, $2. New York: William T. Comstock.

Report of the Proceedings of the Thirty-seventh Annual Convention of the American Railway Master Mechanics' Association. Jos. W. Taylor, Secretary, 667 Rookery, Chicago.

Commercial Relations of the United States with Foreign Countries During the Year 1903. Bureau of Statistics, Department of Commerce and Labor, Washington, D. C.

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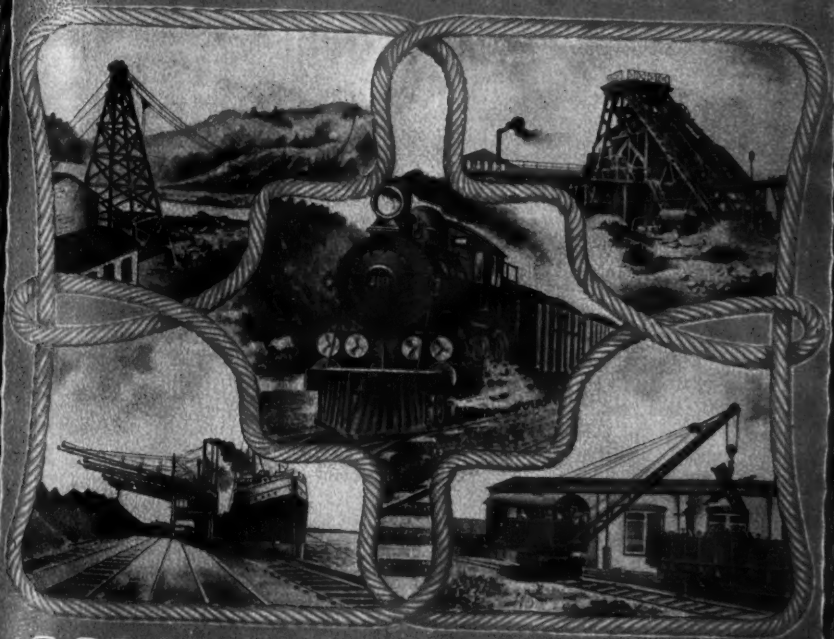

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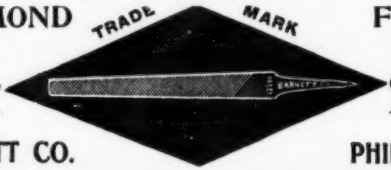

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